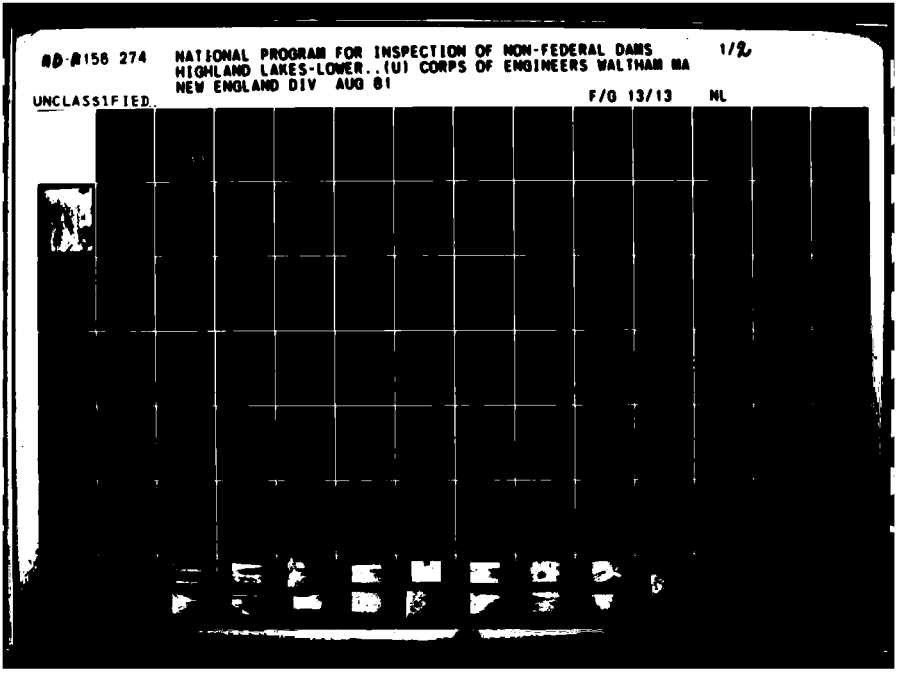
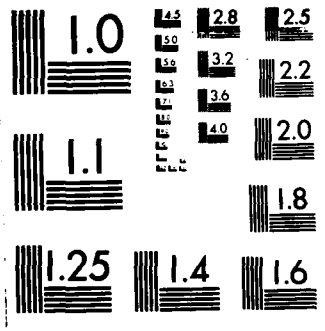
AD-A158 274 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS 1/2
HIGHLAND LAKES-LOWER..(U) CORPS OF ENGINEERS WALTHAM MA
NEW ENGLAND DIV AUG 81

UNCLASSIFIED F/G 13/13 NL





CONNECTICUT RIVER BASIN
GOSHEN, MASSACHUSETTS

HIGHLAND LAKES-LOWER LAKE DAM
MA 00598

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS. 02154

AUGUST 1981

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MA 00598	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Highland Lakes-Lower Lake Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE August 1981 13. NUMBER OF PAGES 55
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Connecticut River Basin
Goshen, Massachusetts
West Branch of Mill River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

THe dam is a 26.5 ft. high, 665 ft. long earth embankment dam with a concrete spillway and a manually operated main drain. It is in generally poor conditton. Indications of seepage were observed under the headwall at the outlet structure and near the downstream toe. The size is intermediate with a hazard potential of high. The upstream vertical masonry wall on the left side of the spillway and the masonry headwall at the toe of the dam have experienced some misalignment.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:
NEDED

SEP 21 1981

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

Inclosed is a copy of the Highland Lakes - Lower Lake Dam (MA-00598) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is vitally important.

Copies of this report have been forwarded to the Department of Environmental Quality Engineering. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Environmental Quality Engineering for your cooperation in this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
BRIEF ASSESSMENT

IDENTIFICATION NO.:	MA 00598
NAME OF DAM:	Highland Lakes-Lower Lake Dam
TOWN:	Goshen
COUNTY AND STATE:	Hampshire, Massachusetts
STREAM:	West Branch of Mill River
DATE OF INSPECTION:	July 8, 1981

The dam is a 26.5 foot high, 665 foot long earth embankment dam with a concrete spillway and a manually operated main drain. The spillway divides the dam into two sections. The section on the right side (main dam) is approximately 1 foot higher than the left side. The dam is believed to have been built prior to 1900 and modified in 1936 and 1972. The dam is owned and operated by the Commonwealth of Massachusetts, Department of Environmental Management.

There was no indepth engineering data available for review. Therefore, the adequacy of the dam was primarily evaluated by visual inspection, past performance history and sound engineering judgement. The visual inspection indicated the dam to be in generally poor conditon. Indications of seepage were observed under the headwall at the outlet structure and near the downstream toe. The upstream riprap is in poor condition. The upstream vertical masonry wall on the left side of the spillway and the masonry headwall at the toe of the dam have experienced some misalignment.

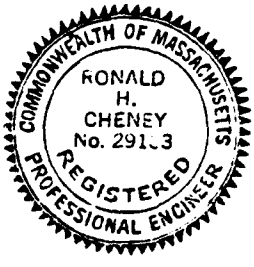
The dam has a size classification of intermediate and a hazard potential classification of high. Based upon Corps Guidelines, the full PMF test flood inflow would be 3330 cfs, from the 1.7 square mile total drainage area. The routed test flood outflow is 1390 cfs, and 1430 cfs, with and without flashboards in place, respectively a· a corresponding surcharge elevation of 1403.8±. The top of the main dam, elevation 1404 is not overtopped. However, the top of the left abutment area, elevation 1403 is overtopped by 0.8 feet. The spillway has a capacity of 800 cfs. The spillway can pass 54 percent of the routed test flood outflow.

The dam is in generally poor condition. It is recommended that the Owner engage a qualified registered professional engineer to investigate and design required remedial measures for: repair of the upstream face of the dam; the source of seepage found at the downstream toe; the movement of the outlet structure masonry headwall at the downstream toe and providing an upstream means of controlling discharge through the drain. The Owner should also engage a qualified registered professional engineer to perform a detailed hydrologic/hydraulic analysis of the project to determine spillway adequacy and overtopping potential and determine the extent of riprap protection required along the downstream toe.

The Owner should institute remedial measures which include: maintenance of brush growth on the downstream slopes and in the spillway channel; restoration of the turf cover between the outlet structure and the crest; filling of sinkholes downstream

of the outlet structure on the right side of the concrete training wall; properly draining of the treed area downstream of the dam on the left side of spillway; repair of spalled concrete at the spillway training walls; instituting of an annual technical inspection program and development of a formal warning system for the downstream impact area.

The recommendations and remedial measures should be implemented by the Owner within one year after receipt of this Phase I Inspection Report.



Ronald H. Cheney, P.E.
Vice President

Hayden, Harding & Buchanan, Inc.
Boston, Massachusetts

This Phase I Inspection Report on Highland Lakes-Lower Lake Dam (MA-00598
has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

J. W. Finegan

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

Aramast Mahtesian

ARAMAST MAHTESIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation: however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to

represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

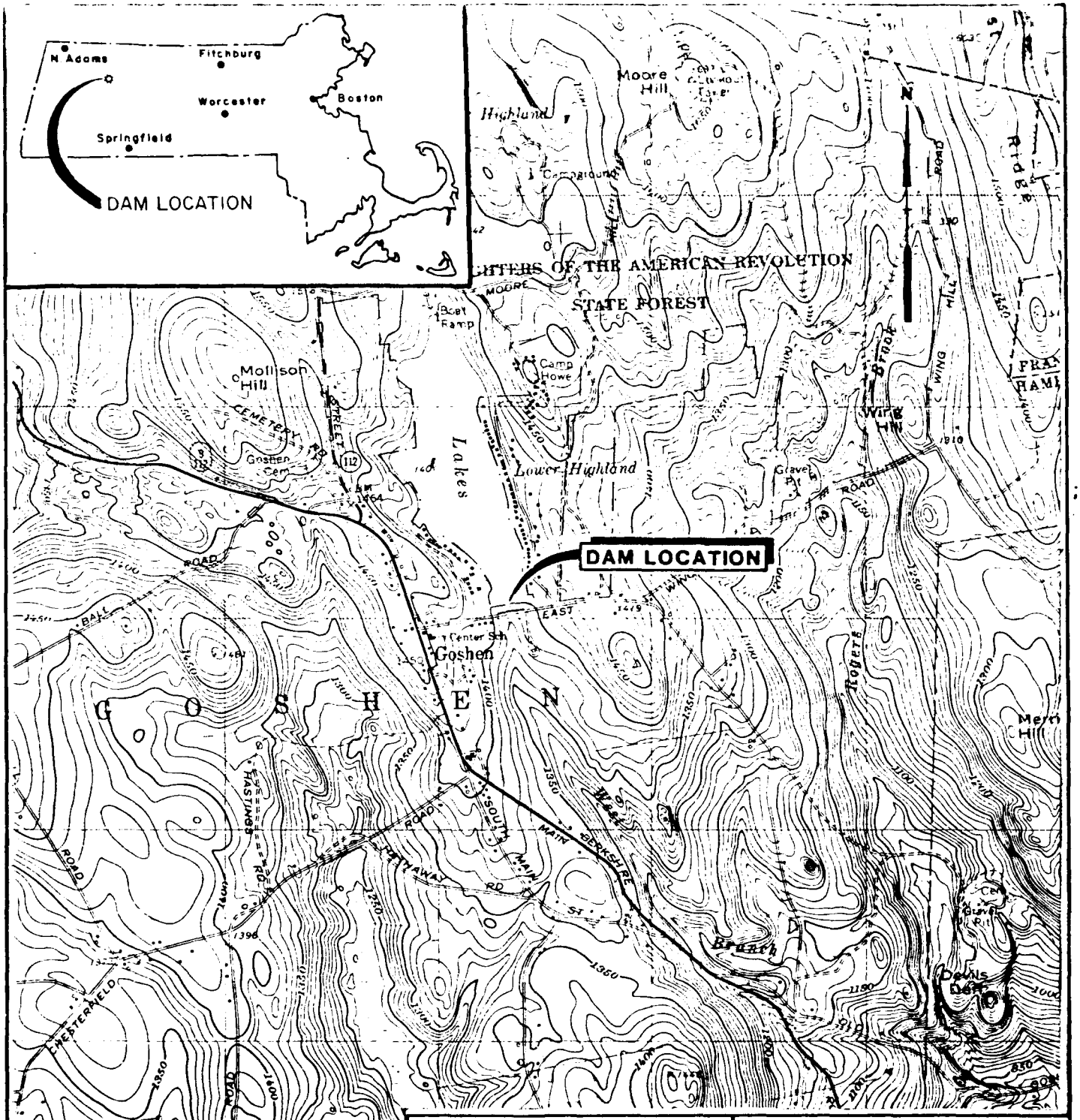
The Phase I Investigation does <u>not</u> include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

TABLE OF CONTENTS

APPENDIXES

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.



HAYDEN, HARDING & BUCHANAN, INC. CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

HIGHLAND LAKES-LOWER LAKE DAM LOCATION PLAN

GOSHEN MASSACHUSETTS

			SCALE: 1 25000
			DATE: AUGUST, 1981

PHASE I

NATIONAL DAM INSPECTION PROGRAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Hayden, Harding & Buchanan, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Hayden, Harding & Buchanan, Inc. on 26 June 1981 by William E. Hodgson Jr., Colonel, Corps of Engineers. Contract No. DACW 33-80-C-0006 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of nonFederal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly, effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location

Highland Lakes Lower Lake Dam is located in the Town of Goshen Massachusetts. It impounds the waters of Lower Highland Lake located off East Street, approximately 1300 feet east of the East Street - Main Street intersection. The dam is shown on the Goshen, Massachusetts U.S.G.S. Quadrangle, with the approximate coordinates of North 42° 26' 32", West 72° 47' 41". The outlet stream from Highland Lakes is the West Branch of the Mill River, which flow about 8 miles southeast to the Mill River in the Town of Leeds.

b. Description of Dam and Appurtenances

The dam is a 26.5 foot high, 665 foot long, earth embankment dam, containing a concrete spillway and a 16 inch drain line.

The embankment is separated into two sections by the spillway. The right side (main dam) is approximately 465 feet long with a 18± foot wide crest. The upstream face is inclined at approximately 2H:1V and is ripraped to within about 4 feet (vertical) of the crest. The crest and downstream face are turf lined. The downstream side slope is variable of approximately 4H:1V. There is a dry stone masonry wall of variable height extending approximately 75 feet left of the outlet pipe (photographs 8 and 14). Extending from this wall there is a concrete

wall, generally about 3 feet high along the toe. This wall also serves as the right training wall of the spillway outlet channel.

The left side embankment is approximately 160 feet long. It has a crest width of about 20 feet and a dry stone masonry wall upstream face as shown by photograph 12. The crest is approximately one foot lower than at the main dam (right side of spillway). The downstream face and the crest are turf lined. The downstream face is inclined at about 2-1/2H:1V.

The spillway, shown in photograph 4, is about 37 feet long. It is comprised of two concrete side sections and a central 8 foot long, 1'-4" deep chute section with provisions for flashboards (See plan B-3). The spillway has concrete training walls. These concrete training walls extend downstream on both sides forming a 22 foot wide spillway outlet channel, which joins with the outlet works channel (see plan B-3).

The outlet works consists of a 18 inch inside diameter cast iron pipe which inlets at the upstream toe. This pipe extends below the embankment, splicing into a 16 inch inside diameter cast iron pipe at about the downstream edge of the crest. This pipe continues downstream under the embankment into a buried 4'-9" by 8'-8" concrete and masonry gate structure. Inside the gate structure the 16 inch pipe joins a 16 x 16 x 6 inch "T" section. The 6 inch pipe feeds into a fire hydrant located approximately 30 feet downstream of the drain outlet. The 16 inch pipe outlets into a downstream channel (photograph

5). Outflow from the 6 and 16 inch pipes are controlled by manually operated butterfly valves within the buried gate structure. (See plan B-5).

c. Size Classification

The dam's size classification is intermediate, based upon its storage capacity of 1750 acre-feet and height of 26 1/2 feet. The size classification is based upon Corps Guidelines for storage capacity (intermediate - 1,000 to 50,000 acre-feet) and hydraulic height (intermediate -40 to 100 feet).

d. Hazard Classification

The dam has a high hazard potential classification due to the potential loss of more than a few lives due to dam failure flooding. It is estimated that at least 5 homes could receive 6 to 10 feet of dam failure flooding damage (above first floor levels). These homes would not be affected by base flow flooding prior to dam failure.

e. Ownership

The dam is owned by the Commonwealth of Massachusetts, Department of Environmental Management, 100 Cambridge Street, Boston, Massachusetts 02202.

f. Operator

The designated caretaker of the dam is Mr. Alan Hendry, Superintendant of the Daughters of the American Revolution (D.A.R.) State Forest in Goshen. The address is

Daughters of the American Revolution, State Forest, Department of Environmental Management Headquarters, East Street, Goshen, Massachusetts 01032. Telephone (413) 268-7098.

g. Purpose of Dam

The purpose of this dam is for recreation.

h. Design and Construction History

The dam is believed to have been built prior to 1900. Design plans dated May 1935, indicate proposed repairs to the spillway, relocation of the gate structure and modifications to the upstream and downstream side slopes and the spillway discharge channel. As-built plans dated September 1, 1972, indicate that the gate structure controls were modified and a 6 inch buried outlet pipe leading to a downstream hydrant was added at that time.

i. Normal Operational Procedures

The caretaker installs 16 inches of flashboards at the spillway in the spring and removes them in the fall. The 16 inch outlet pipe is normally closed, except for 3 or 4 days each year in the beginning of October, when it is opened to lower the lake level to allow shorefront residents to make repairs. The valve of the 6 inch pipe feeding the downstream fire hydrant is normally open, so the hydrant is under pressure.

1.3 Pertinent Data

a. Drainage Area

The 0.8 s.m. (528 acre) hilly drainage area contributes runoff directly to the lower lake. The upper lake (drainage area of 0.9 s.m.) has two outlets, one empties into the

lower lake and contributes "controlled runoff". These lakes and most of their drainage areas are part of the D.A.R. State Forest. Several roads and numerous homes (along the lower lake shore line) are within the generally undeveloped drainage area.

b. Discharge at Dam Site

1. Outlet Works

The outlets located at the dam are the 16 inch drain pipe and the spillway. The 16 inch outlet (capacity of 15± cfs at elevation 1404) discharges at the concrete/stone headwall structure located at the downstream toe of the dam. The invert elevation of this pipe at its outlet is 1379.0.

The concrete spillway is about 37 feet long with provisions for 1'-4" of flashboards at an 8 foot long chute section. The elevation of the spillway crest (top of flashboards) is 1400.0. There is 4 feet of freeboard between the spillway crest and top of main dam, elevation 1404. The left abutment area is 3 feet higher than the spillway crest, at elevation 1403. There are normally 1'-4" of flashboard at the spillway during the spring and summer which are removed in the fall.

2. Maximum Known Flood at Dam Site

There are no records of maximum flood at the dam. The United States Weather Bureau records indicate that about 11 inches of rainfall occurred near the general location of the dam from September 17 to 22, 1938.

3. Ungated Spillway Capacity at Top of Dam

The ungated spillway capacity with water to the top of dam, elevation 1404, is 760± cfs with the 1'-4" x 8'-0" flashboards in the lower chute. Without the flashboards, the capacity is 800 ± cfs.

With the water level at elevation 1403, top of left abutment, the spillway capacity is 500 and 540 cfs, with and without flashboards, respectively.

4. Ungated Spillway Capacity at Test Flood Elevation

The ungated spillway capacity with water at the test flood elevation of 1403.8 and flashboards in place is 740± cfs. The left abutment of the dam is overtopped by 0.80 feet. Without flashboards, the capacity is 780± cfs.

5. Gated Spillway Capacity at Normal Pool Elevation

Not applicable

6. Gated Spillway Capacity at Test Flood Elevation

Not applicable

7. Total Spillway Capacity at Test Flood Elevation

See Section 1.3.b.4 above.

8. Total Project Discharge at Top of Dam

With the main drain open and chute flashboards in place, the total project discharge with water at the top of main dam, elevation 1404, is 1565± cfs. Under the conditions, without flashboards, the discharge is 1605± cfs.

9. Total Project Discharge at Test Flood Elevation

At the test flood elevation 1403.8±, the total project discharge with the main drain open and no flashboards in place is 1430± cfs. With flashboards in place, the discharge is 1390± cfs.

c. Elevation (feet above NGVD elevations are approximate)

(1)	Streambed at toe of dam	1377.5
(2)	Bottom of cutoff	Unknown
(3)	Maximum tailwater	Unknown
(4)	Recreation pool	1400.0
(5)	Full flood control pool	N/A
(6)	Spillway crest (16"x8' lower spillway) (main spillway)	1398.7 1400.0
(7)	Design surcharge (original Design)	Unknown
(8)	Top of dam (Main Dam) (Left Side of Dam)	1404 1403
(9)	Test flood surcharge	1403.8

d. Reservoir (Length in feet)

(1)	Normal pool	4000
(2)	Flood control pool	N/A
(3)	Spillway crest pool	4000
(4)	Top of dam	4100
(5)	Test flood pool	4100

e. Storage (acre-feet)

(1)	Spillway crest (elev. 1400)	1350
(2)	Normal pool (elev. 1400)	1350
(3)	Top of dam (main section elev. 1404) (left side elev. 1403)	1750 1640
(4)	Test flood pool (elev. 1403.8)	1725

(5) Flood control pool ---------- N/A

f. Reservoir Surface (acres)

(1) Spillway crest (elev. 1400) ---------- 100

(2) Normal pool (elev. 1400) ---------- 100

(3) Top of dam (elev. 1404) ---------- 110
(elev. 1403) ---------- 107

(4) Test flood pool (elev. 1403.8) ------- 110

(5) Flood control pool ---------- N/A

g. Dam

(1) Type ---------- Earth embankment, masonry

(2) Length ---------- 670'

(3) Height ---------- 26.5'

(4) Top Width ---------- 18'±

(5) Side Slopes ---------- U.S. 2H:1V and Vertical
--- D.S. variable approximately 4H:1V

(6) Zoning ---------- Unknown

(7) Impervious Core ---------- Unknown

(8) Cutoff ---------- Unknown

(9) Grout curtain ---------- Unknown

h. Diversion and Regulating Tunnel - none at this project

i. Spillway

(1) Type ---------- concrete broadcrested

(2) Length of weir ---------- 37'

(3) Crest elevation ---------- 1400.0
flashboards controlled 1'-4" x 8'x0"
lower chute ---------- 1398.7

(4) Gates ---------- None

(5) U/S Channel - none ------- opens directly to lake

(6) D/S channnel ----- 22' wide, riprapped, discharge channel along toe of dam

j. Regulating Outlets

The 16 inch outlet pipe is regulated by a manual gate located inside the underground structure at the downstream toe of dam. The gate is reported to be operable and is normally kept closed.

The invert at the pipe outlet is at elevation 1378.5±. With the water level at elevation 1404, top of main dam, the pipe has a capacity of 15± cfs.

SECTION 2

ENGINEERING DATA

2.1 Design Data

There were no records indicating when or by whom the dam was designed and no design calculations were located. Design plans for proposed 1936 modifications to the spillway, gate structure and downstream side slope were made available by the Division of Forests & Parks, Amherst, Massachusetts Office. As-built plans dated September 1972, indicating modifications to the gate structure were made available at the Department of Environmental Management Boston Office.

2.2 Construction Data

As-built plans dated September 1972 indicating modifications to the gate structure were available. No other construction data was located for this dam.

2.3 Operation Data

No operational manual was located for this dam.

2.4 Evaluation of Data

a. Availability

No indepth engineering data was located. Design plans for dam modifications, dated May 1935, were made available at the Division of Forests & Parks, Amherst, Massachusetts. As-built plans for gate structure modifications were made available at the

Department of Environmental Management, 100 Cambridge Street, Boston, Massachusetts 02202. State Inspection Reports for the years 1972, 1974 and 1977 were made available at the Department of Environmental Quality Engineering, Division of Waterways, 100 Nashua Street, Boston, Massachusetts 02114.

b. Adequacy

The lack of indepth engineering data does not allow for a definitive review. Therefore, the adequacy of this dam, structurally and hydraulically, can not be assessed from the standpoint of review of design calculations, but must be based primarily on the visual inspection, past performance history, and sound engineering judgement.

c. Validity

The visual inspection of this facility showed no reason to question the validity of the information supplied on the State Inspection Reports or the design plans and as-built plans.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General

The dam was visually inspected on July 8, 1981. At the time of the inspection, the water level of the reservoir was approximately at the top of the 14 inches of flashboards in place at the spillway.

b. Dam

The dam is an earth embankment with a length of 665 feet, a height of 26.5 feet and a crest width of about 18 feet.

An operating spillway is located on the dam about 160 feet from the left abutment.

1. Upstream Slope

The upstream face of the dam on the right side of the spillway has a slope of 2H:1V and is shown above the reservoir level in Photograph 7. The riprap protection generally extends one to two feet above the spillway crest elevation but has experienced numerous collapses resulting from erosion and sloughing of the soil on the slope. A typical section of the upstream riprap is shown in Photograph 10 where an area of the slope has sloughed and the riprap collapsed.

Numerous small holes generally less than 2 feet deep are present near and above the water level as shown in Photographs 9 and 17.

Between the spillway and the left abutment, the upstream slope includes a vertical masonry wall for a portion of the dam height. This wall is shown in Photograph 12. A portion of the masonry wall has collapsed and the slope behind the wall shows signs of subsidence in this area.

2. Crest

The crest of the dam, shown in Photograph 2, is grass covered and generally well maintained. No settlement or cracking of the crest was observed. The elevation of the crest on the left side of the spillway is about 1 foot lower than the crest on the right side of the spillway.

3. Downstream Slope

The downstream face of the dam on the right side of the spillway has a slope of about 4H:1V. The slope, shown in Photograph 3 is grass covered and generally well maintained. The spillway channel makes an abrupt turn at the downstream toe and flows along the downstream toe of the dam. A low masonry wall forms the toe of the dam along the spillway discharge channel. Several areas of wetness and unmeasurably small seepage of clear water was observed near the toe of the dam above the spillway channel. One such area is shown in Photograph 13. On a subsequent visit to the dam on July 31, 1981, these wet areas were not present.

Between the spillway and the left abutment, the downstream slope is overgrown with brush, Photograph 2. The area downstream of the toe is wet in some areas, resulting from slight seepage through the dam or poor drainage in this area.

c. Appurtenant Structures

1. Spillway

The riprap protection on the right side of the spillway upstream of the concrete training wall has collapsed, as shown in Photograph 11. The spillway discharge channel is lined with stone on the bottom and has low masonry training walls. The channel bottom and walls are overgrown with brush. The section of the channel immediately downstream of the crest is shown in Photograph 6.

The concrete at the spillway crest was in generally good condition. Some spalled concrete was observed along the training walls are shown by Photograph 15.

2. Outlet

The outlet structure, located at the downstream toe of the dam, is shown in Photograph 5 and 8. The outlet pipe is located near the bottom of the concrete section of the headwall shown in Photograph 8.

A flow of several gallons per minute of clear water was occurring below the concrete headwall and outlet

pipe. According to the operator, the outlet is operable and used last in October 1980. There is no upstream control for regulating flow through the drain.

The left side of the masonry portion of the headwall appears to be leaning downstream.

d. Reservoir Area

There are no indications of instability along the banks of the reservoir in the vicinity of the dam.

e. Downstream Channel

The spillway discharge channel flows along the toe of dam. It joins the outlet channel immediately downstream of the outlet structure, and the combined flow is channeled under the road through a 4 foot diameter pipe shown by Photograph 16. Between the outlet structure and the road, the channel floor is overgrown with brush.

3.2 Evaluation

Visual inspection indicates that the dam is in poor condition. The inspection disclosed the following items which require attention:

a. The upstream riprap is in poor condition and the upstream slope has experienced several small sloughs and sinkholes. This condition could eventually lead to instability of the upstream slope.

b. The upstream vertical masonry wall on the left side of the spillway has experienced some misalignment and a collapse of one section has occurred. Some subsidence

of the slope behind the wall has resulted. Further deterioration could eventually lead to a slope failure of the dam.

c. Significant seepage is occurring under the headwall of the outlet structure at the toe of the dam. Other areas of seepage and wet areas near the toe of the dam were observed. This seepage, if left unattended, could result in instability of the dam.

d. Continued movement of the masonry headwall at the toe of the dam could evenually lead to collapse of this structure and instability of the downstream slope.

e. As there is no upstream control for the drain, the line is always under pressure. A leak within this line could lead to a piping condition and possible failure of the dam.

f. The spillway channel outflow along the toe of dam could overtop the short training wall protecting the downstream toe of dam. This could lead to erosion of the downstream toe resulting in instability of the dam.

SECTION 4

OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General

The purpose of the dam is for recreation. Typically, 16 inches of flashboard are in place during the spring and summer to control the water surface elevation. Flashboards are removed in the fall. The 16 inch drain is opened once a year in early October and left opened for approximately 4 days to allow for maintenance and repairs for the cottages located on the shores of the lake.

b. Description of Warning System in Effect

There are no warning systems at this dam.

4.2 Maintenance Procedures

a. General

The dam is maintained by the Daughters of the American Revolution State Forest (Department of Environmental Management). Normal maintenance includes cutting of grass on the crest and side slopes.

b. Operating Facilities

There is no formal operational procedure for this facility. The caretaker regulates the height of flashboards at the spillway for summer and winter use and lowers the lake once a year from lake shore property maintenance.

4.3 Evaluation

There is no formal maintenance and operational procedure. The caretaker maintains the grass turf and according to the caretaker, the gate for the drain is operable. The Owner should institute a program of annual technical inspection and a downstream warning and evacuation plan.

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General

Highland Lakes-Lower Lake Dam is located just east of Routes 9 and 112 in the northeast section of the Town of Goshen. The lake is part of the D.A.R. State Forest. The lake receives uncontrolled runoff from the adjacent 0.8 s.m. (528 acres) drainage area and controlled runoff from the upper lake, 0.9 s.m. (575 acres) drainage area.

The dam's outlet stream is the West Branch of the Mill River. It flows about 8 miles southeasterly into the Mill River in the Town of Leeds.

5.2 Design Data

The dam was originally constructed prior to 1900. No design data was found.

5.3 Experience Data

No records of rainfall or flood stage were located for this dam.

5.4 Test Flood Analysis

The dam has a size classification of intermediate (based upon its storage capacity of 1750 acre-feet) and a hazard potential of high due to the potential loss of more than a few lives from an assumed dam failure. Based upon Corps Guidelines,

the test flood would be the full PMF. Runoff is developed from Corps Guidance of 3000 csm/s.m. for drainage areas under 1 s.m. in size. Test flood inflow from the uncontrolled 0.8 s.m. drainage area (2460 cfs) and "controlled" discharge (870 cfs) from the upper lake outlet is 3330 cfs. The routed test flood outflow with flashboards in place at the 1'-4" x 8' chute is 1390± cfs, at elevation 1403.8. About 740± cfs (54 percent of outflow) is discharged from the spillway area. The remaining 655± cfs discharge overflows the left abutment area.

Without the 1'-4" x 8' chute flashboards in place, the test flood outflow would be 1430± cfs, at elevation 1403.8±.

5.5 Dam Failure Analysis

This dam was determined to have a high hazard potential. There is a potential for the loss of more than a few lives due to dam failure flooding. The dam was assumed to have failed with the water level at top of dam, elevation 1404. The failure discharge of 27,520 cfs is developed by assuming a breach length of 120 feet for the 26.5 foot high dam.

Just prior to dam failure, discharge from the spillway and left abutment area will be about 1600 cfs. This flow, plus about 500 cfs runoff from the drainage area (73 cfs/s.m. from 6.8 ± s.m. area) along the outlet channel, will cause significant flooding and damage homes along the channel prior to dam failure.

Between the dam and station 150+00, there are no buildings near the channel. However, two local roads and several

undeveloped roads could be overtopped. From station 150+00 to 220+00 there is no development along the channel. A small dam at Graham Pond (station 200+00±) could be overtopped.

Significant development occurs between station 220+00 and 240+00 (limit of this study). Here, many homes and buildings are located along the outlet channel. Just prior to dam failure flooding, base flood flooding stage will be seven feet deep. About eight homes will receive up to six feet of flood damage (above first floor levels).

Dam failure flooding will cause the total flood stage to reach depths of about 15 feet, including base flow flood depth. Failure flow causes a flood stage increase of eight feet. The eight homes damaged by base flow will receive further damage due to dam failure flooding.

At this location, at least five homes receive flood damage due to dam failure flood water only. Dam failure flood depths at these homes could be six to ten feet above first floor level. There is a significant potential for the loss of more than a few lives due to an assumed dam failure.

Beyond the area studied, past station 240 + 00, additional dam failure flood damage can occur as the flood water flows toward the developed areas of the Town of Williamsburg and Leeds.

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

The visual inspection indicates the following potential structural problem:

a. Sloughing of the upstream slope and collapse of the riprap could lead to instability of the upstream slope.

b. Continued deterioration of the upstream vertical masonry wall left of the spillway could lead to instability of the dam in this area.

c. The presence of seepage below the outlet structure and at other areas along the downstream toe of the dam, if left unattended, could lead to failure of the dam.

d. Continued movement of the vertical masonry headwall at the outlet structure could lead to instability of the downstream slope.

e. The spillway channel outflow along the toe of dam could overtop the short training wall protecting the downstream toe of the dam. This could lead to erosion of the downstream toe resulting in instability of the dam.

6.2 Design and Construction Data

There is no information available on the design and construction of the original dam. However, significant post con-

struction changes were made in the 1930's and are discussed below. The evaluation of the dam is based on the limited information available concerning the present design of the dam and on the visual inspection.

6.3 Post Construction Changes

Significant post construction changes occurred in about 1935. Drawings dated May 1935 by the Department of the Interior National Park Service were reviewed, and the following changes are noted therein:

a. The downstream slope of the dam consisted of a vertical masonry wall located at about the present downstream side of the crest. The present downstream earth embankment was constructed during the renovation project.

b. The spillway was modified and the discharge channel relocated to its present location.

c. The outlet structure at the downstream toe was constructed.

d. The upstream slope was regraded and resurfaced with riprap.

In 1972, additional renovation work was performed on the outlet structure. A drawing prepared by the Commonwealth of Massachusetts Department of Natural Resources dated October 25, 1971 and revised on September 1, 1972 to indicate as-built conditions indicates that the following work was performed.

a. Modifications were made to the existing gatehouse and the door of the gatehouse was concreted.

b. New piping was installed including a valve and a tee supplying a fire hydrant.

6.4 Seismic Stability

The dam is located within Seismic Zone 2 and in accordance with the recommended Phase I guidelines does not require seismic stability analysis.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, REMDIAL MEASURES

7.1 Dam Assessment

a. Condition

On the basis of the visual inspection and the available information, the dam is judged to be in poor condition.

b. Adequacy of Information

The information available, together with the visual inspection, is adequate for a Phase I level investigation.

c. Urgency

The recommendations presented in Sections 7.2 and 7.3 should be implemented by the Owner within one year after receipt of this Phase I Inspection Report.

7.2 Recommendations

a. The Owner should engage a qualified registered professional engineer to investigate and design required remedial measures for:

1. Repair of the upstream face of the dam on both sides of the spillway, including all holes.
2. The source of seepage found at the toe of the dam and beneath the outlet structure.
3. The movement of the outlet structure masonry headwall at the downstream toe of the dam.
4. Providing an upstream means for controlling discharge through the drain.

b. The Owner should engage a qualified registered professional engineer to perform a detailed hydraulic/hydrologic study to determine spillway adequacy and overtopping potential and determine the extent of riprap protection required along the downstream toe.

The Owner should implement the recommendations of the Engineer.

7.3 Remedial Measures

a. Operating and Maintenance Procedures

1. Brush growth on the downstream slope left of the spillway and in the spillway channel should be cut as part of routine annual maintenance.
2. The turf cover between the outlet structure and the crest should be restored.
3. Sinkholes downstream of the outlet structure on the right side of the concrete training wall should be filled.
4. The treed area downstream of the dam on the left side of the spillway should be properly drained so that the significance of the wetness in this area can be evaluated.
5. Spalled concrete along the spillway training walls should be repaired.
6. The Owner should institute a program of annual technical inspection.

7. The Owner should develop a formal warning and evacuation plan for downstream areas in case of an emergency.

7.4 Alternatives

There are no practical alternatives for these recommendations and remedial measures.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT HIGHLAND LAKES - LOWER LAKE

DATE July 8, 1981*

TIME 1 p.m.

WEATHER Sunny - 90°

W.S. ELEV. 1400 U.S. ____ DN.S.

PARTY:

1. Ron Cheney - HHB
2. Dave Vine - HHB
3. Mike Angieri - HHB
4. Karl Dalenberg - GEI
5. Ray Moran - Dept. Envirn. Mgt.
6. ____
7. ____
8. ____
9. ____
10. ____

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam Embankment	R.C., D.V., M.A., K.D.	
2.	Outlet Works	R.C., D.V., M.A., K.D.	
3.	Spillway	R.C., D.V., M.A., K.D.	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

* Subsequent inspection by D. LaGatta and K. Dalenberg of GEI on July 31, 1981

PERIODIC INSPECTION CHECKLIST

PROJECT HIGHLAND LAKES - LOWER LAKE DATE July 8, 1981

PROJECT FEATURE Dam Embankment NAME K. Dalenberg, D. Vine

DISCIPLINE Geotechnical, Structural , Hydraulic NAME R. Cheney, M. Angieri

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	1404
Current Pool Elevation	1400±
Maximum Impoundment to Date	Unknown
Surface Cracks	Cracks associated with small sloughs on upstream slope.
Pavement Condition	No pavement.
Movement or Settlement of Crest	Settlement behind retaining wall on upstream face left of spillway.
Lateral Movement	None observed.
Vertical Alignment	Collapse of part of retaining wall on upstream slope 60 ft from spillway.
Horizontal Alignment	Good.
Condition at Abutment and at Concrete Structures	Good.
Indications of Movement of Structural Items on Slopes	None.
Trespassing on Slopes	Path on downstream slope on right side of outlet.
Sloughing or Erosion of Slopes or Abutments	Several small sloughs near water line on upstream slope. Some holes up to 1-ft diameter on upstream slope.
Rock Slope Protection - Riprap Failures	Several collapses of riprap on upstream slope near waterline. Collapse of upstream retaining wall 60 ft east of spillway.
Unusual Movement or Cracking at or Near Toe	Outlet fieldstone headwall leaning downstream.
Unusual Embankment or Downstream Seepage	1. Wet area below toe east of spillway. 2. Seepage and wet areas near toe above spillway channel.
Piping or Boils	None observed.
Foundation Drainage Features	None observed.
Toe Drains	None observed.
Instrumentation System	None observed.
Vegetation	Small brush near retaining wall left of spillway and on downstream slope left of spillway.

PERIODIC INSPECTION CHECKLIST

PROJECT HIGHALND LAKES - LOWER LAKE DATE July 8, 1981

PROJECT FEATURE Intake NAME K. Dalenberg, D. Vine

DISCIPLINE Geotechnical, Structural, Hydraulic NAME R. Cheney, M. Angieri

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	
Slope Conditions	Below water.
Bottom Conditions	Below water.
Rock Slides or Falls	Below water.
Log Boom	Below water.
Debris	Below water.
Condition of Concrete Lining	Below water.
Drains or Weep Holes	Below water.
b. Intake Structure	
Condition of Concrete	Below water.
Stop Logs and Slots	Below water.

PERIODIC INSPECTION CHECKLIST

PROJECT HIGHLAND LAKES - LOWER LAKE DATE July 8, 1981

PROJECT FEATURE Control Tower NAME K. Dalenberg, D. Vine

DISCIPLINE Geotechnical, Structural, Hydraulic NAME R. Cheney, M. Angieri

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	There is none at the project.
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECKLIST

PROJECT HIGHLAND LAKES - LOWER LAKE DATE July 8, 1981

PROJECT FEATURE Outlet Works NAME K. Dalenberg, D. Vine

DISCIPLINE Geotechnical, Structural, Hydrauli NAME R. Cheney, M. Angieri

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	
General Condition of Concrete	There is none at this project.
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECKLIST

PROJECT HIGHLAND LAKES - LOWER LAKE DATE July 8, 1981

PROJECT FEATURE Outlet Structure NAME K. Dalenberg, D. Vine

DISCIPLINE Geotechnical, Structural, Hydraulic NAME R. Cheney, M. Angieri

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Fair to good. Adjacent dry masonry wall in generally good condition.
Rust or Staining	None observed.
Spalling	Minor.
Erosion or Cavitation	Some at seepage area.
Visible Reinforcing	None observed.
Any Seepage or Efflorescence	Seepage was observed under the headwall.
Condition at Joints	Good.
Drain holes	None observed.
Channel	Overgrown with brush.
Loose Rock or Trees Overhanging Channel	None.
Condition of Discharge Channel	Discharge channel flows in 4-ft diameter pipe below street about 40 ft downstream of outlet headwall.

PERIODIC INSPECTION CHECKLIST

PROJECT HIGHLAND LAKES - LOWER LAKE DATE July 8, 1981

PROJECT FEATURE Outlet Works NAME K. Dalenberg, D. Vine

DISCIPLINE Geotechnical, Structural, Hydraulic NAME R. Cheney, M. Angieri

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Below water. Riprap upstream of right training wall has collapsed.
Loose Rock Overhanging Channel	None.
Trees Overhanging Channel	None.
Floor of Approach Channel	Below water.
b. Weir and Training Walls	
General Condition of Concrete	Good.
Rust or Staining	None observed.
Spalling	Some on training wall.
Any Visible Reinforcing	None observed.
Any Seepage or Efflorescence	None observed.
Drain Holes	None.
c. Discharge Channel	
General Condition	Overgrown with brush.
Loose Rock Overhanging Channel	None.
Trees Overhanging Channel	None.
Floor of Channel	Riprap bottom overgrown with small brush.
Other Obstructions	None.
Other Comments	

PERIODIC INSPECTION CHECKLIST

PROJECT HIGHLAND LAKES - LOWER LAKE DATE July 8, 1981

PROJECT FEATURE Service Bridge NAME K. Dalenberg, D. Vine

DISCIPLINE Geotechnical, Structural, Hydraulic NAME R. Cheney, M. Angieri

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	There is none at this project.
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Underside of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B

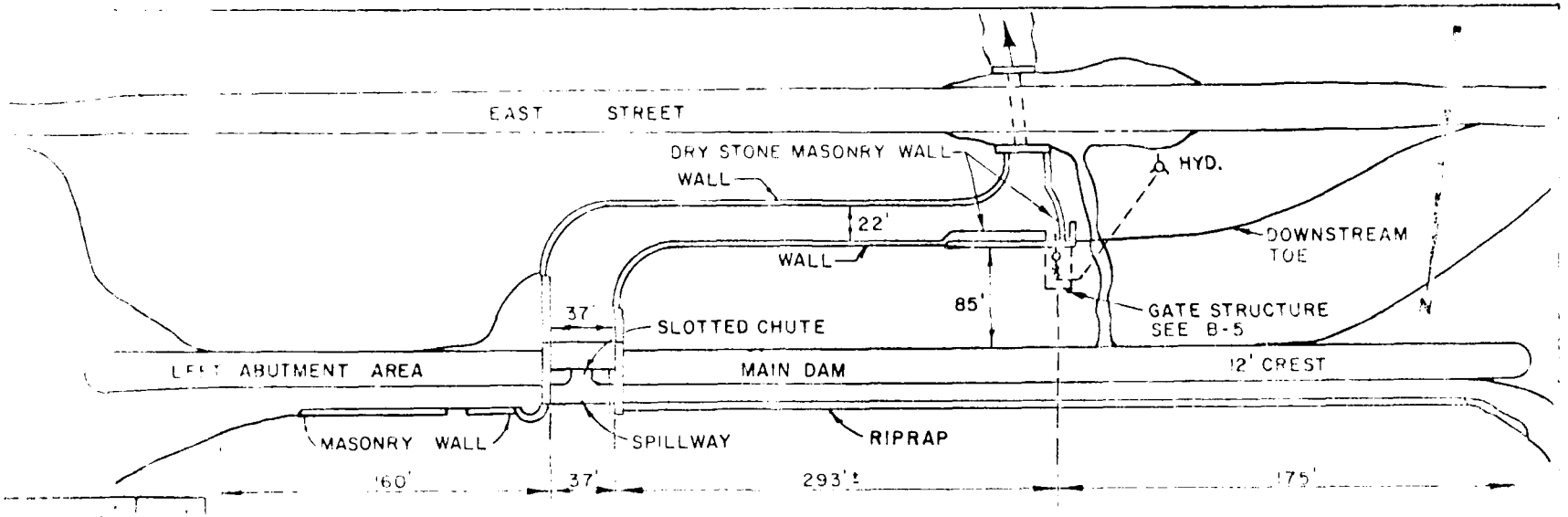
ENGINEERING DATA

LIST OF AVAILABLE ENGINEERING DATA

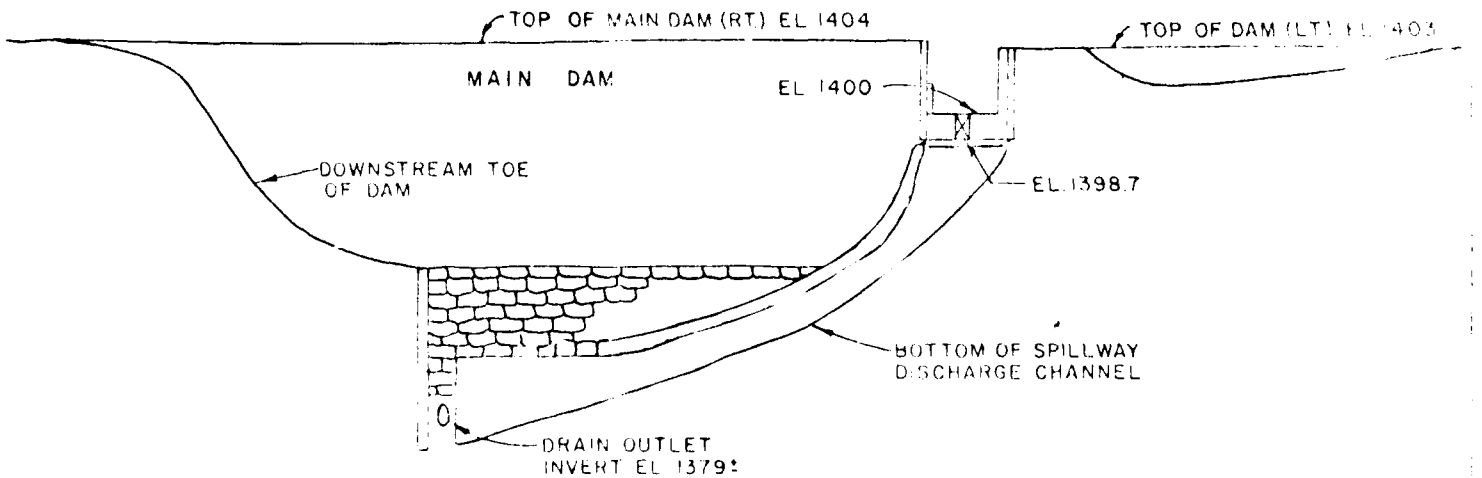
1. Design plans for dam modifications dated May 1935 were made available at the Division of Forests and Parks, Amherst, MA

2. As-built plans for gate structure modifications dated September 1972 were made available at the Department of Environmental Management, 100 Cambridge Street, Boston, Massachusetts

3. State Inspection Reports for the years 1972, 1974 and 1977 were made available at the Department of Environmental Quality Engineering, Division of Waterways, 100 Nashua Street, Boston, Massachusetts.

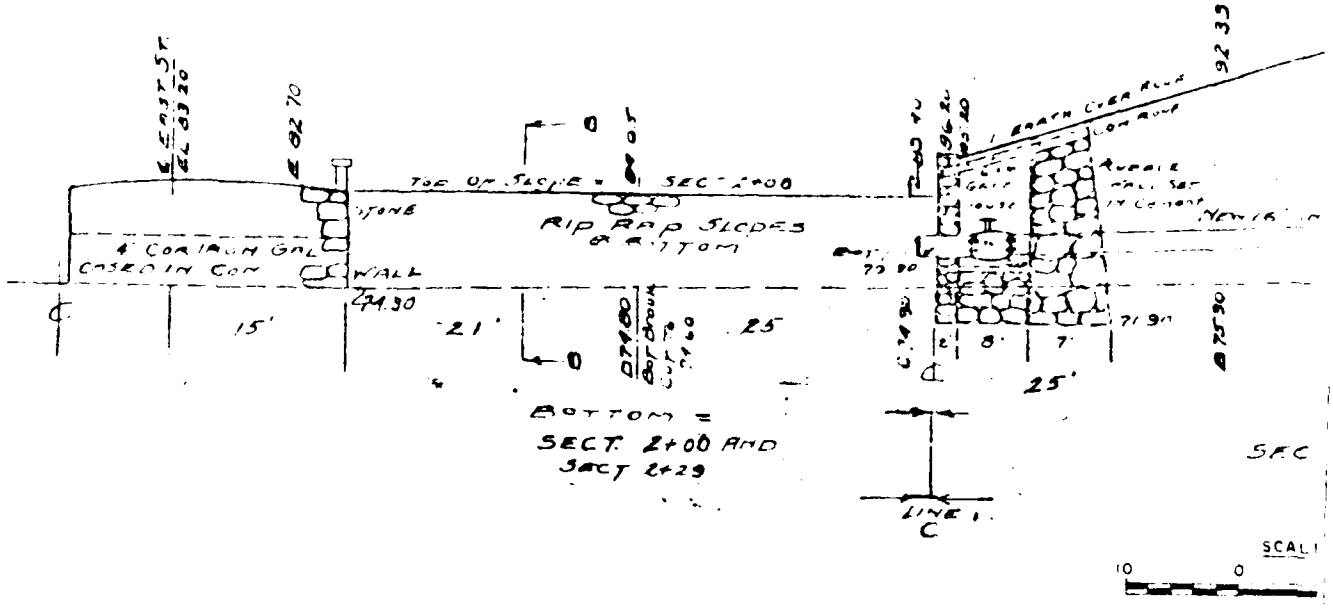


PLAN

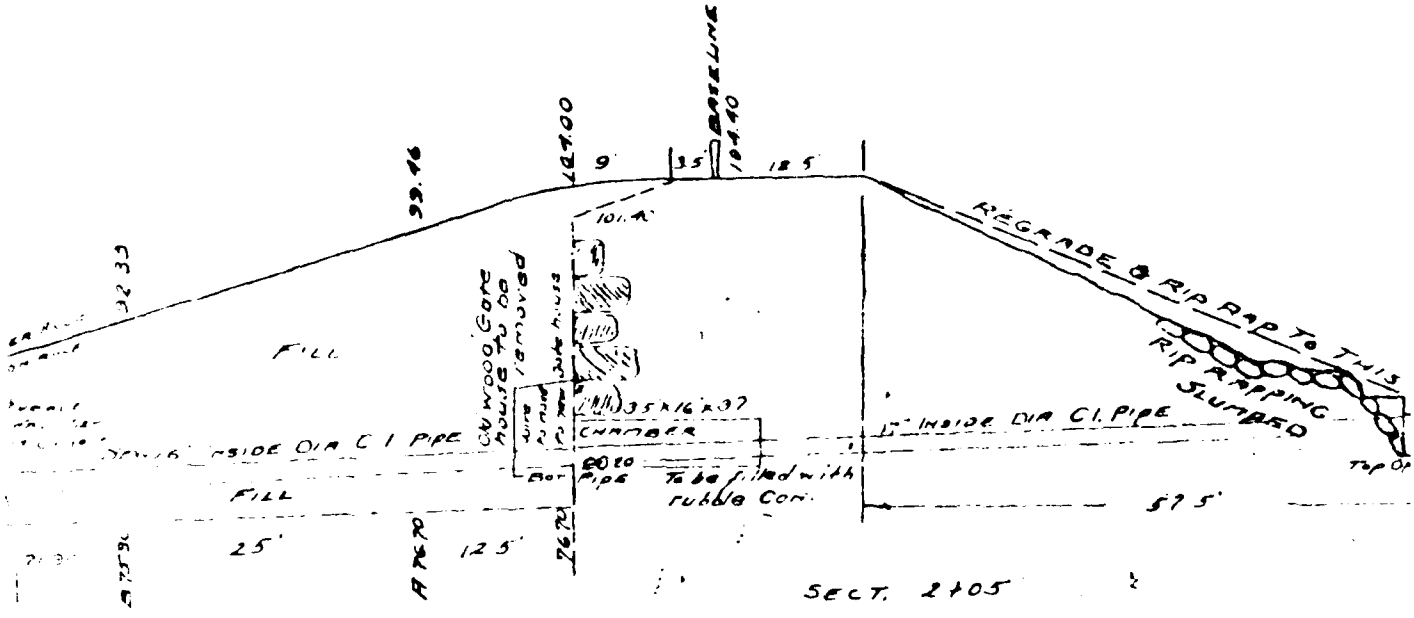


ELEVATION OF DAM

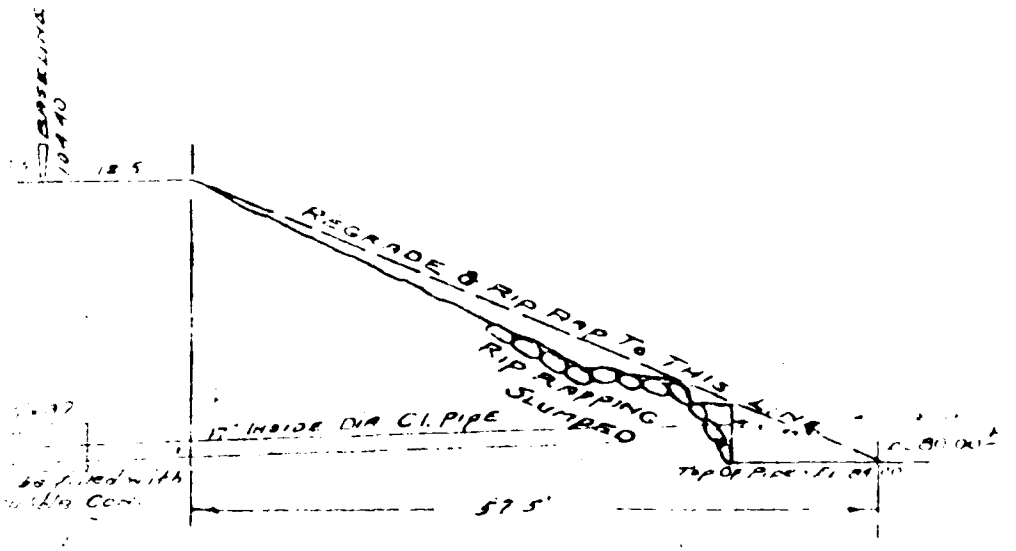
FIG. 1 - MID LAKES - LOWER LAKE DAM
PLAN AND PROFILE



1 of 2



HAYDEN, HARDING & BUCHANAN, INC CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	US A
NATIONAL PROGRAM OF INSPEC	
HIGHLAND LAKES-LO SECTION AT GA	
GOSHEN	



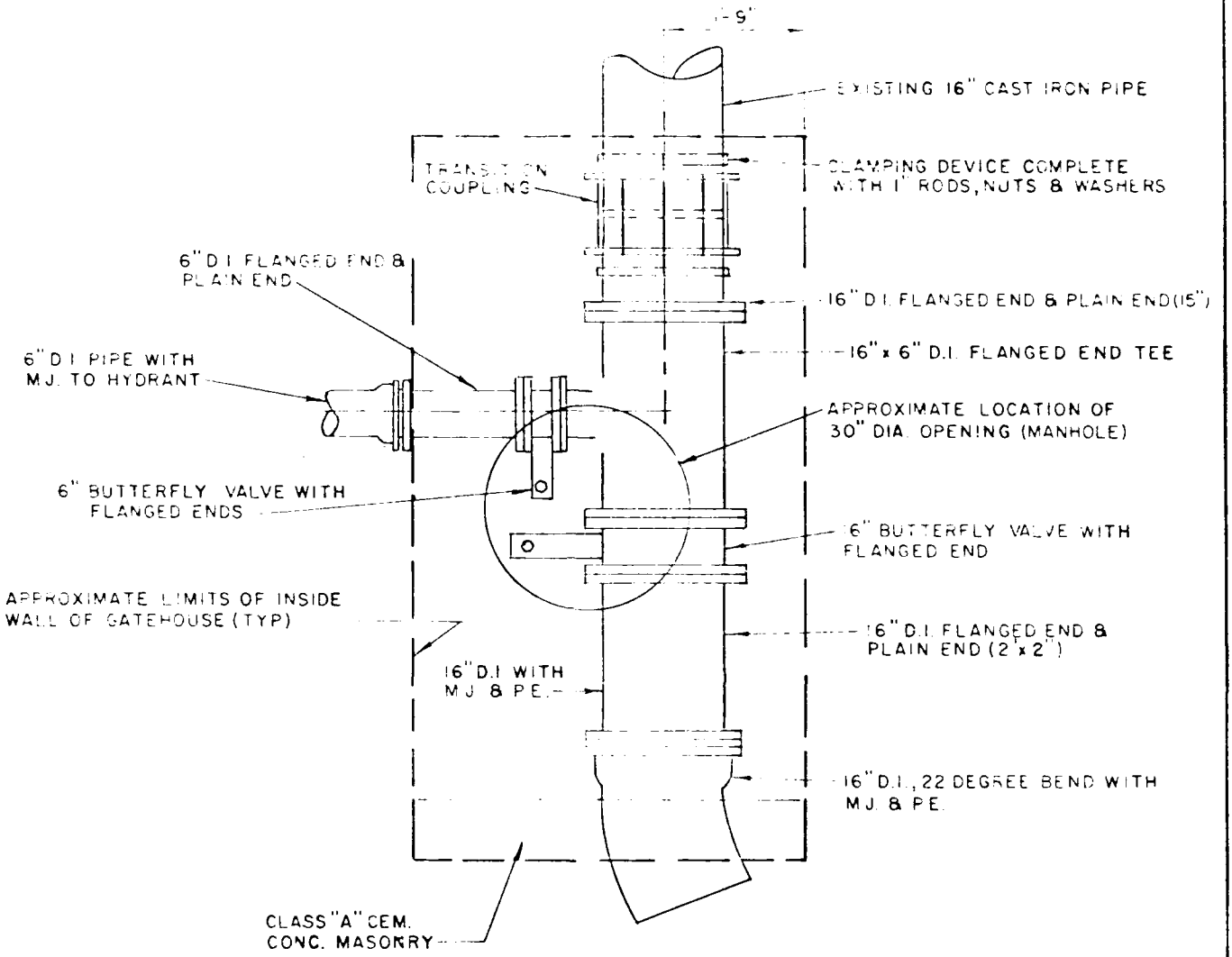
SECT. 2+05

HAYDEN, HARDING & BUCHANAN, INC CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	US ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

HIGHLAND LAKES-LOWER LAKE DAM
SECTION AT GATEHOUSE

GOSHEN MASSACHUSETTS



GATEHOUSE PIPING DETAILS

SCALE 1/2"=1'-0"

HAYDEN, HARDING & BUCHANAN, INC. CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

HIGHLAND LAKES-LOWER LAKE DAM
GATEHOUSE PIPING DETAILS

[illegible] MASSACHUSETTS

SCALE AS SHOWN

DATE AUGUST, 1981

The Commonwealth of Massachusetts

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGR.
DIVISION OF WATERWAYS

100 Nashua Street, Boston 02114

February 14, 1977

Commonwealth of Massachusetts
Department of Environmental Management
100 Cambridge Street
Boston, Massachusetts 02202

Re: Insp. Dam #2-8-103-3
Highland Lakes - Lower Dam
Goshen

Dear Sir:

On October 13, 1976 , an Engineer from the Massachusetts Department of Public Works made a visual inspection of the above dam. Our records indicate the owner to be Commonwealth of Mass., Dept. Env. Management. If this information is incorrect, will you please notify this office.

The inspection was made in accordance with the provisions of Chapter 253 of the Massachusetts General Laws as amended (Dams Safety Act). Chapter 706 of the Acts of 1975 transferred the jurisdiction of the so-called "Dams Safety Program" to the Commissioner of the Department of Environmental Quality Engineering.

The results of the inspection indicate that this dam is conditionally safe. The following conditions were noted that require attention:

SEE REVERSE SIDE OF SHEET FOR

"REMARKS AND RECOMMENDATIONS"

We call these conditions to your attention before they become serious and more expensive to correct. With any correspondence please include the number of the dam as indicated above.

Very truly yours,

John A. Hannon, P.E.
Chief Engineer

cc: F. J. Hoey, D.H.E. Dist. 2
R. Salls, D.D.E. Dist. 2
File
Mr. Alan Hendry, Supt.
D.A.R. State Forest
D.E.M. Headquarters
East St., Goshen, Mass.

(OVER)

B-6

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

~~City~~/Town Goshen. County Hampshire. Dam No. 2-8-108-3.

Name of Dam Highland Lakes-Lower Dam.

Topo Sheet No. 8 8. Coordinates: Mass. Rect. N 529,400, E 230,300.

Inspected by: Harold T. Shumway, On Oct. 13,1976. Date Last Inspection 10-9-74.

2. OWNER/S: As of Oct. 13, 1976

per: Assessors_____, Reg. of Deeds_____, Prev. Insp. X, Per. Contact X.

	Name	St. & No.	City/Town	State	Tel. No.
1.	Commonwealth of Massachusetts Department of Environmental Management	100 Cambridge St.	Boston	Mass.	
2.					
3.					

3. CARETAKER: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name	St. & No.	City/Town	State	Tel. No.
Mr. Alan Hendry, Supt. of D.A.R. State Forest, D.E.M. Hdqtrs.	East Street	Goshen	Mass.	

4. DATA:

No. of Pictures Taken None. Sketches See description of Dam.
Plans, Where D.E.M. office has plan for repair work done in 1972.

5. DEGREE OF HAZARD: (if dam should fail completely)*

1. Minor_____.
2. Moderate_____.
3. Severe X.
4. Disastrous_____.

Comments: Water would be confined by steep side slopes until it reached Mill River which flows through dense residential areas. Approximately 207 million gallons impoundment.

*This rating may change as land use changes (future development).

6. OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: 170'± westerly of East end of dam-concrete chute overflow spillway-36'wide X 3'± high.

Controls Yes, TYPE: 3 ea. 6" high X 8' long stoplogs across low level weir notch 18" deep in center of spillway.

Automatic ____. Manual X. Operative Yes X, No ____.

Comments: No stoplogs in place at time of inspection.

No. 2 Location and Type: Approx. 275'± west of spillway-15" dia. C.I. pipe conduit-outlet invert 25½' below top of dam.

Controls Yes, Type: Gate valve in vault.

Automatic ____. Manual X. Operative Yes X, No ____.

Comments: New valve installed in 1972-operable per word of caretaker-Intake for hydrant is a y on drawdown conduit, upstream of valve.

No. 3 Location and Type: ____.

Controls ____, Type: ____.

Automatic ____. Manual ____. Operative Yes ____, No ____.

Comments: ____.

Drawdown present Yes X, No ____. Operative Yes X, No ____.
Comments: See No. 2 above.

---

7. DAM UPSTREAM FACE: Slope 2:1 on turf, Vertical on stone masonry walls. Depth Water at Dam 20'± at drawdown intake.

Material: Turf X. Brush & Trees ____. Rock fill ____. Masonry (Stone) X. Wood ____.

Other Dumped stone fill on slope below water line.

Condition: 1. Good ____. 3. Major Repairs ____.

2. Minor Repairs X. 4. Urgent Repairs ____.

Comments: Grade of stone fill rather irregular-several small depressions along top of embankment.

---

8. DAM DOWNSTREAM FACE: Slope 4:1 variable.

Material: Turf X. Brush & Trees ____. Rock Fill ____. Masonry (Stone) X. Wood ____.

Other Short dry stone masonry wall both sides of gate vault.

Condition: 1. Good ____. 3. Major Repairs X.

2. Minor Repairs ____. 4. Urgent Repairs ____.

Comments: Stone masonry face wall tilting-areas of seepage-leaks and a possible piping condition evident. B-8

(9.) EMERGENCY SPILLWAY: Available No. Needed No.

Height Above Normal Water _____ Ft.

Width _____ Ft. Height _____ Ft. Material _____.

Condition: 1. Good _____. 3. Major Repairs _____.

2. Minor Repairs _____. 4. Urgent Repairs _____.

Comments: Chute spillway appears to have been more than adequate for many years.

(10.) WATER LEVEL AT TIME OF INSPECTION: 6 Ft. Above _____. Below X.

Top Dam X F.L. Principal Spillway _____.

Other _____.

Normal Freeboard 4½ to 5 Ft.

(11.) SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment None found.

Animal Burrows and Washouts None found.

Damage to Slopes or Top of Dam Several areas of small depressions caused from digging by small children-no hazard to dam.

Cracked or Damaged Masonry Concrete masonry sidewall of drawdown drain channel cracked and tilted-stone masonry face wall shifting.

Evidence of Seepage Seepage noted on downstream slope and at toe on west portion of embankment.

Evidence of Piping See remarks.

Leaks Flow of several G.P.M. beneath 15" C.I. pipe outlet.

Erosion Minor erosion of upstream slope from wave and ice action.

Trash and/or Debris Impeding Flow None found.

Clogged or Blocked Spillway None found.

Other _____.

(12.) OVERALL CONDITION:

1. Safe_____.
2. Minor repairs needed_____.
3. Conditionally safe - major repairs needed_____X_____.
4. Unsafe_____.
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list_____.

(13.) REMARKS AND RECOMMENDATIONS: (Fully Explain)

The general maintenance of this dam appears very good. The embankment and slopes are well turfed and no brush growth was evident anywhere. There was several small depressions 6" to 8" in diameter-noted along the upstream edge of the top of dam. These were apparently created by small children digging into the embankment this past summer season per Mr. Hendry, Supt. of the D.A.R. State Forest, who was present during a portion of the inspection. These holes are only a few inches deep and will be filled and tamped this fall per Mr. Hendry. A depression around the manhole cover of the gate vault has been refilled.

The short stone masonry dry wall running easterly from the gate vault has started to shift or tilt outward at the top. This is a retaining wall and it appears that back pressure from the embankment slope behind and above the wall is pushing the top of the wall outward.

The stream of water of several G.P.M. issuing from under the 15" C.I. drawdown pipe is still evident. This condition has been noted in past inspection reports and appears to be approx. the same in volume as noted two years ago. Approximately 8'± down stream from end of 15" pipe what appears to be a small boil was noted in the bed of the drainage channel for the draw down pipe. The channel bed is paved with large stones and there exists a possibility that this boil is the result of water action from the large leak beneath the pipe upstream. However, occasional soil particles were noted in this boil and the leakage flow issuing from beneath the 15 inch pipe appears to be clear. This would appear to indicate a possible piping condition exists. The existance of the boil was brought to the caretaker's attention during the inspection and he stated that a constant check would be maintained, both on the boil and the large leak, for any sudden change or increase in either one.

A concrete retaining wall on the westerly side of the drainage channel is severely cracked and broken a few feet downstream from its union with the concrete gate vault.

This wall is starting to tilt toward the ditch and seepage evidence was noted along the wall.

Because of several areas of seepage which were noted, coupled with the large leak beneath the 15" C.I. pipe, and what appears to be a boil in bed of drainage channel, the District rates this dam as conditionally safe-major repairs needed.

HTS/at

Box 484
Amherst, Mass. 01002

TO: Bruce S.Gullion, Director
FROM: Kenneth M.Dubuque, Regional Supervisor

SUBJECT: INSPECTION DAM #2-8-108-3 GOSHEN
HIGHLAND LAKES, LOWER DAM

DATE: January 13, 1975

Reply letter to Commissioner Brownell from Malcolm E.Graf.

The 1972 repairs to the dam had nothing to do with controlling the seepage through the dam. These repairs or alterations were to replace the gate valve that had become worn by excessive use, it used to be the only way to control the water depth during the entire year, and the installing of a fire hydrant for the Town of Goshen.

This seepage through the dam was brought to the Department's attention in 1968 by Hampshire County Engineer, George McDonald of Tighe & Bond, Holyoke. At that time considerable time was spent by Mr. McDonald and myself trying to locate the exact location of same, without definite results although it was thought by Mr. McDonald it was coming from the spillway chute just below the dam apron and following along a stonewall, that was in the old original dam before the C.C.C. reconstructed same in the late 1930's, and coming out near the drain which is the location of the present seepage problem. We were told to keep close check on this seepage, which we have been doing, when Public Works took over the inspections this was discussed at length with them.

I would assume from the last report of inspection that conditions have become a great deal worse and immediate steps should be taken to correct this condition as this is a very large body of water and if the dam did breech could cause untold damage, the loss of many lives, it could wipe out Williamsburg Village, Haydenville and part of Northampton.

Could you tell me the disposition of this problem.

Kenneth M.Dubuque
Regional Supervisor

KMD/elf
c.c. R.Correia
M.Graf, P.W.D.

FRANCIS W. SARGENT
GOVERNOR

ARTHUR W. BROWNELL
COMMISSIONER

The Commonwealth of Massachusetts

Department of Natural Resources

Leverett Saltonstall Building
100 Cambridge Street, Boston 02202

November 18, 1974

L. Andrinico

Mr. Malcolm Graf, P.E.
Associate Commissioner
Department of Public Works
Office of the Commissioner
100 Nashua Street
Boston, Massachusetts 02114

Dear Mal:

Thank you for your letter of November 8th concerning the inspection of the Highland Lakes Lower Dam at the D.A.R. State Forest.

I am quite surprised that the repairs that we made in 1974 do not appear to be effective.

Therefore, I am requesting the Division of Acquisition and Construction to reassess the entire matter.

Sincerely,

Arthur W. Brownell
Commissioner

AWB:BSG:mk

November 8, 1974

Arthur W. Brownell, Commissioner
Department of Natural Resources
100 Cambridge Street
Boston, Massachusetts

RE: Inspection-Dam #2-8-108-3
Goshen
Highland Lakes Lower Dam

Dear Commissioner Brownell:

On October 9, 1974, an engineer from the Massachusetts Department of Public Works made a visual inspection of the above dam.

The inspection was made in accordance with Chapter 253 of the Massachusetts General Laws as amended by Chapter 595 of the Acts of 1970 (Dams-Safety Act).

The results of the inspection indicate that an investigation followed by corrective repairs is necessary. The following conditions were noted that require attention:

1. Directly below the 15" C.I. outlet pipe, water is flowing under or through a break in the concrete wall. There are three separate flows, one about 1½ feet westerly of the pipe, another under the pipe and one about 1½ feet easterly of the pipe. The easterly flow could be described as a boil as it contained soil particles.

2. At several locations water seeps out of the embankment slope in sufficient amounts to flow over the top of the spillway chute sidewall.

3. On top of the easterly embankment about 35 feet from the spillway and directly behind the upstream stone facewall there is a small sump hole. The toe area of this embankment is wet and about opposite the sump hole there is an area of standing water about 15 to 20 feet from the toe.

It now appears that the 1962 repairs have not been effective in controlling the seepage through the dam. It is suggested that an in-depth evaluation of the seepage condition be conducted and corrective repairs made.

Very truly yours,

MALCOLM E. GRAF, P.E.
Associate Commissioner

xxx NLD
LRA:jmp
cc: Mr. Hendrick, Superintendent
F. J. Hoey
R. Salls

July 14, 1972

Arthur W. Brownell, Commissioner
Department of Natural Resources
100 Cambridge Street
Boston, Massachusetts

RE: Inspection of Dam #2-8-108-3
Goshen
Highland Lake Lower Dam

Dear Commissioner Brownell:

An engineer from the Massachusetts Department of Public Works has inspected the above dam in Goshen, of which the Department of Natural Resources is the owner.

The repair work to the dam appears satisfactory. It has been noted in previous inspection reports that boiling exist in the stream bed below the drawdown gate structure. At the time of inspection additional seepage was observed at the downstream toe approximately 75 feet westerly of the drawdown structure. It is suggested that an evaluation of this condition be conducted and corrective measures be undertaken if necessary.

Very truly yours,

MALCOLM E. GRAF
Associate Commissioner

MA:pan
cc: J. J. Hoey DE #2
R. Gallo, Dist. #2

Leo R. Andronico, Assistant Civil Engineer

Fred. C. Schwalm, P.E., Deputy Chief Engineer June 28 72

Dam #2-8-108-3
Goshen
Highland Lake Lower Dam

As requested by Mr. Russell Salls, District #2 Dams and Reservoir Engineer, I visited the above dam on Friday, June 23, 1972.

Reference is made to the attached letter, dated June 22, 1972, from District Highway Engineer Francis J. Hoey, to Associate Commissioner Graf to which I concur.

Mr. Salls expressed concern over a bubbling condition noted in previous inspection reports, located downstream of the drawdown structure in the old stream bed. Seepage was observed at the toe approximately 100 ft. westerly of the drawdown structure. It is my recommendation that an in-depth investigation be conducted to evaluate the extent of seepage. The Department of Natural Resources, the owners of the Dam, will be so notified.

Respectfully submitted,

Leo R. Andronico

Leo R. Andronico
Assistant Civil Engineer

FCS

LRA:pan
Enclosure:
cc: F. J. Hoey, DHE #2
R. Salls, Dist. #2

June 22, 1972

SUBJECT: Review of
Highland Lake Dam-
Lower Lake 2-8-108-3
Goshen

Mr. Malcolm Graf
Associate Commissioner for Waterways
Mass. Dept. of Public Works
100 Nashua Street
Boston, Massachusetts 02114

ATTENTION: Mr. F. C. Schwelm
Deputy Chief Engineer for Waterways

Dear Sir:

At the request of Mr. Everett E. Sporbert, Sector Director, Civil Defense Agency, an engineer from this office viewed the Highland Lake Dam, Lower Lake, Dam No. 2-8-108-3, a large, about 450 foot long, 20 foot high earth embankment dam, with a free board of about 3 feet. This dam is controlled by the Department of Natural Resources and because of work in progress on the dam, local people have become concerned with its safety.

A project to replace the old drawdown gate has been suspended, apparently because of complications in blocking off the sluiceway entrance out in the lake. Work is expected to resume as soon as the contractor's diver is available, since the sluiceway entrance is under about twenty feet of water. There is an open excavation about eight feet square and ten feet deep exposing the sluiceway just above the downstream toe of the embankment and about seventy-five feet from the edge of the water. On June 21, 1972 the bottom of the excavation had a minimum of standby water and no flow was observed from the sides of the excavation. An earth berm prevented surface water from the embankment slope from flowing into the embankment.

Other than the above excavation, the condition of the dam appeared to be unchanged from that described in the 1970 report of the County's Consulting Engineer which stated that it was in satisfactory condition and safe.

June 22, 1972

SUBJECT: Review of
Highland Lake Dam-
Lower Lake 2-8-108-3
Goshen
Mr. Malcolm Graf - Page 2

After our review of the dam, Mr. Sporbert was advised that under foreseeable circumstances the integrity of the Highland Lake Lower Dam does not appear to be affected by the present work.

Very truly yours,

Francis J. Hoey

FRANCIS J. HOEY, P.E.
District Highway Engineer

RCS/fm

C-DSH
HEB

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

~~City~~/Town Goshen. County Hampshire. Dam No. 2-8-108-3.

Name of Dam Highland Lakes Dam - Lower Dam.

Topo Sheet No. 8B. Coordinates: Mass. Rect. N 528,400, E 230,300.

Inspected by: Russell C. Salls, P.E., On Oct. 9, 1974. Date Last Inspection 1972.

---

2. OWNER/S: As of 1972

per: Assessors_____, Reg. of Deeds_____, Prev. Insp._____, Per. Contact X_____.

1. Commonwealth of Massachusetts, Department of Natural Resources, 100 Cambridge Street, Boston, Massachusetts
   Name | St. & No. | City/Town | State | Tel. No.

2. _____
   Name | St. & No. | City/Town | State | Tel. No.

3. _____
   Name | St. & No. | City/Town | State | Tel. No.

---

3. CARETAKER: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Mr. Hendrick, Superintendent of D.N.R. State Forest, D.N.H. Hdqtrs., East St., Goshen, Mass.
Name | St. & No. | City/Town | State | Tel. No.

---

4. DATA:

No. of Pictures Taken None. Sketches See description of Dam.
Plans, Where Department of Natural Resources has plan for repair work done in 1972.

---

5. DEGREE OF HAZARD: (if dam should fail completely)*

1. Minor_____.
2. Moderate_____.
3. Severe X_____.
4. Disastrous_____.

Comments: Failure of this dam would release a large amount into the Mill River which flows through developed area in Williamsburg and Northampton.

*This rating may change as land use changes (future development).

(6.) OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: Chute overflows spillway about 170' from east or left end. Opening 36' - 10" wide and 3' high.

Controls Yes, TYPE: Stoplogs 15" high - 8' wide across low level - weir notch 18" deep in center spillway.

Automatic ____. Manual X. Operative Yes X, No ____.

Comments: Spillway head structure concrete, chute below has concrete sidewalls and teleford stone paved bottom.

No. 2 Location and Type: About 275'± west of spillway - 15" C.I. Pipe conduit outlet flow line 25½' below top embankment.

Controls Yes, Type: Gate valve in valve vault.

Automatic ____. Manual X. Operative Yes X, No ____.

Comments: New valve installed in 1972. Intake for hydrant at bottom downstrea slope on edge East St. is Y on drawdown conduit upstream of valve.

No. 3 Location and Type: ____

Controls ____, Type: ____

Automatic ____. Manual ____. Operative Yes ____, No ____.

Comments: ____

Drawdown present Yes X, No ____. Operative Yes X, No ____.
Comments: See No. 2 Above.

(7.) DAM UPSTREAM FACE: Slope 2:1 - Turfed, Depth Water at Dam 20' @ drawdown Vertical stone masonry east of spillway pipe inta

Material: Turf X. Brush & Trees ____. Rock fill ____. Masonry X. Stone Wood ____.

Other ____

Condition: 1. Good X. 3. Major Repairs ____.

2. Minor Repairs ____. 4. Urgent Repairs ____.

Comments: Small sink hole in top embankment just behind stone wall about 40' east of spillway.

(8.) DAM DOWNSTREAM FACE: Slope 4:1 Variable.

Material: Turf X. Brush & Trees ____. Rock Fill ____. Masonry ____. Wood ____.

Other ____

Condition: 1. Good ____. 3. Major Repairs ____.

2. Minor Repairs X. 4. Urgent Repairs ____.

Comments: Slope east of spillway bottom portion is being cleared of brush. Several areas of seepage evident.

(9.) EMERGENCY SPILLWAY: Available No. Needed No.

Height Above Normal Water_____Ft.

Width_____Ft. Height_____Ft. Material_____.

Condition: 1. Good_____. 3. Major Repairs_____.

2. Minor Repairs_____. 4. Urgent Repairs_____.

Comments: Uncontrolled drainage area very small in relation to size of pond.

Capacity of overflow chute spillway large.

(10.) WATER LEVEL AT TIME OF INSPECTION: 4½ - 5 Ft. Above_____. Below X.

Top Dam X F.L. Principal Spillway_____.

Other Top of earth embankment.

Normal Freeboard 4½ - 5 Ft.

(11.) SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment Few noted on slope east of spillway being cut.

Animal Burrows and Washouts None Noted.

Damage to Slopes or Top of Dam Small sump hole - 1' deep, 1½' diam. - about 30' east of spillway just behind stone upstream facewall.

Cracked or Damaged Masonry Downstream concrete wall of gate vault has opening at bottom with flow of water under wall. See Below.

Evidence of Seepage Yes. Seepage flow on downstream slopes and toe both east and west of spillway. See Remarks.

Evidence of Piping See seepage and leaks.

Leaks Yes. There were several noticeable streams flowing from under concrete sidewall of gate vault under outlet 15" C.I. Pipe. One boil about a foot east of pipe has visible soil particles in it.

Erosion None Noted.

Trash and/or Debris Impeding Flow None.

Clogged or Blocked Spillway No.

Other Seepage through embankment between spillway and drawdown conduit sufficient to cause a noticeable flow over concrete sidewall of spillway chute.

(12.) OVERALL CONDITION:

1. Safe_____.
2. Minor repairs needed_____.
3. Conditionally safe - major repairs needed X.
4. Unsafe_____.
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list_____.

(13.) REMARKS AND RECOMMENDATIONS: (Fully Explain)

Maintenance on this dam appears to be good. The main or westerly embankment has been mowed and guard posts are in place preventing vehicles from driving on to the bottom of the embankment. Clearing away of a small amount of brush on the downstream slope of the east embankment is in progress and apparently being done by Natural Resource's personnel as time is available. No debris was observed in the spillway chute or on the embankments.

Mr. Hendrick, the Superintendent of the D. N. R. State Forest was not available until our inspection was completed. He was able to tell us that he had investigated the wet spot 75 feet westerly of the drawdown conduit, which we commented on after our June, 1972 inspection. He said that he had located a spring up on the westerly side or abutment slope which was causing the very wet area observed and had installed a blind drain from the spring draining into the brook just upstream of the 4 foot ACCM culvert under East Street. It appears that this drain has eliminated the wet spot.

Mr. Hendrick also told us that the hydrant located at the edge of the hard surface about 60 feet westerly of the drawdown structure is supporting water by means of a pipe from a "Y" fitting on the drawdown conduit located upstream of the new drawdown gate so that water is available at the hydrant without opening any gates.

Directly below the 15" C.I. drawdown pipe outlet water is flowing from under or through a break in the concrete wall. There are three separate flows, one about 1½ foot west of the pipe, one under the pipe and one about 1½ foot east of the pipe. The easterly flow could be described as a boil and it contained soil particles. This or a similar condition was reported by the County Engineer in his 1970 Inspection Report and he noted that it had existed for some time. Since this flow could easily be the result of seepage alongside the drawdown conduit and occasionally contains soil particles, we feel that the dam's condition should be Number 3 - Major Repairs Necessary.

RCS/js/sd

13. REMARKS AND RECOMMENDATIONS: (CONTINUED)

An investigation as to the source and extent of the possible hazards due to this flow appears to be required.

At several places water was seeping out of the embankment slope in sufficient amounts to flow over the top of the spillway chute sidewall. Vegetation indicates that this area is generally wet.

On the top of the easterly embankment about 35 feet from the spillway and immediately behind the upstream stone facewall there is a small sump hole of recent origin. It is about 1½ foot in diameter and 1 foot deep. The toe area of this embankment is wet and about opposite the sump hole there is an area of standing water about 15 to 20 feet from the toe.

RCS/sd

DESCRIPTION OF DAM

DISTRICT II .

Submitted by Russell C. Salls, P. E. Dam No. 2-8-108-3

Date October 9, 1974 ~~City~~/Town Goshen

Name of Dam Highland Lakes Dam - Lower Dam

1. Location: Topo Sheet No. 8B Mass. Rect. Coordinates N 528,400 E 230,300

Provide 8½" x 11" in clear copy of topo map with location of Dam clearly indicated.

About 200 feet north of East Street about 1500 feet easterly from Main Road, Route 9. Pond is source of Mill River.

2. Year built Unknown - Was old dam of Hampshire Reservoir Co. so apparently built before 1900. Year/s of subsequent repairs 1972 Drawdown gate replaced gate valve.

3. Purpose of Dam: Water Supply _____ Recreational X Flood Control _____ Irrigation _____ Other formerly Reservoir Dam impounding water for later release into Mill River for use by mills in Williamsburg and Leeds.

4. Drainage Area: 1.67 sq. mi. _____ acres.

Type: City, Bus. & Ind. _____ Dense Res. _____ Suburban _____ Rural, Farm 15%

Wood & Scrub Land 85% Slope: Steep 60% Med. 25% Slight 15%

5. Normal Ponding Area: 91± Acres; Ave. Depth Say 7'

Impoundment: 207 Million gals.; 637 acre ft.

Silted in: Yes X No _____ Approx. Amount Storage Area 5%

6. No. and type of dwellings located adjacent to pond or reservoir _____

i.e. summer homes etc. 75 Cottages, 1 - 4H Club Camp plus other recreational facilities

7. Dimensions of Dam: Length 656' Max. Height 26½'

Freeboard 4½' to 5'

Slopes: Upstream Face 2:1

Downstream Face 4:1 Generally

Width across top 19' to 20'

Dam No. 2-8-108-3

8.

Classification of Dam by Material:

Earth X Conc. Masonry X Stone Masonry _____

Timber _____ Rockfill Spillway _____ Other Stone paved slopes upstream face.

8A.

Dam Type: Gravity X Straight X Curved, Arched _____ Other _____

Overflow _____ Non-overflow X

9.

A. Description of present land usage downstream of dam:

85 % rural; 15 % urban Developed

B. Is there a storage area or flood plain downstream of dam which could accommodate the impoundment in the event of a complete dam failure? Yes _____ No X

C. Character Downstream Valley: Narrow X Wide _____ Developed 15%

Rural 85% Urban _____

10.

Risk to life and property in event of complete failure.

No. of people 20 - 30 in Williamsburg and Northampton.

No. of homes 20 - 30 in Williamsburg and Northampton.

No. of businesses 10 - 15 Retail Businesses.

No. of industries 5 - 6 Type Printing, small manufacturing, etc.

No. of utilities All Type Electrical and Telephone Lines, Electrical Substation, Water and Sewerage Mains.

Railroads None

Other dams Williamsburg plus 7 dams in Northampton. All on Mill River except for Graham Pond - No. 2-8-340-1 and Brass Mill Pond - No. 2-8-340-4 in Graham Pond.

Other Numerous Bridges on Town Ways and on Route 9 - a State Highway.

11.

Attach Sketch of dam to this form showing section and plan on 8½" x 11" sheet.

RCS/vk/sd

Attachments

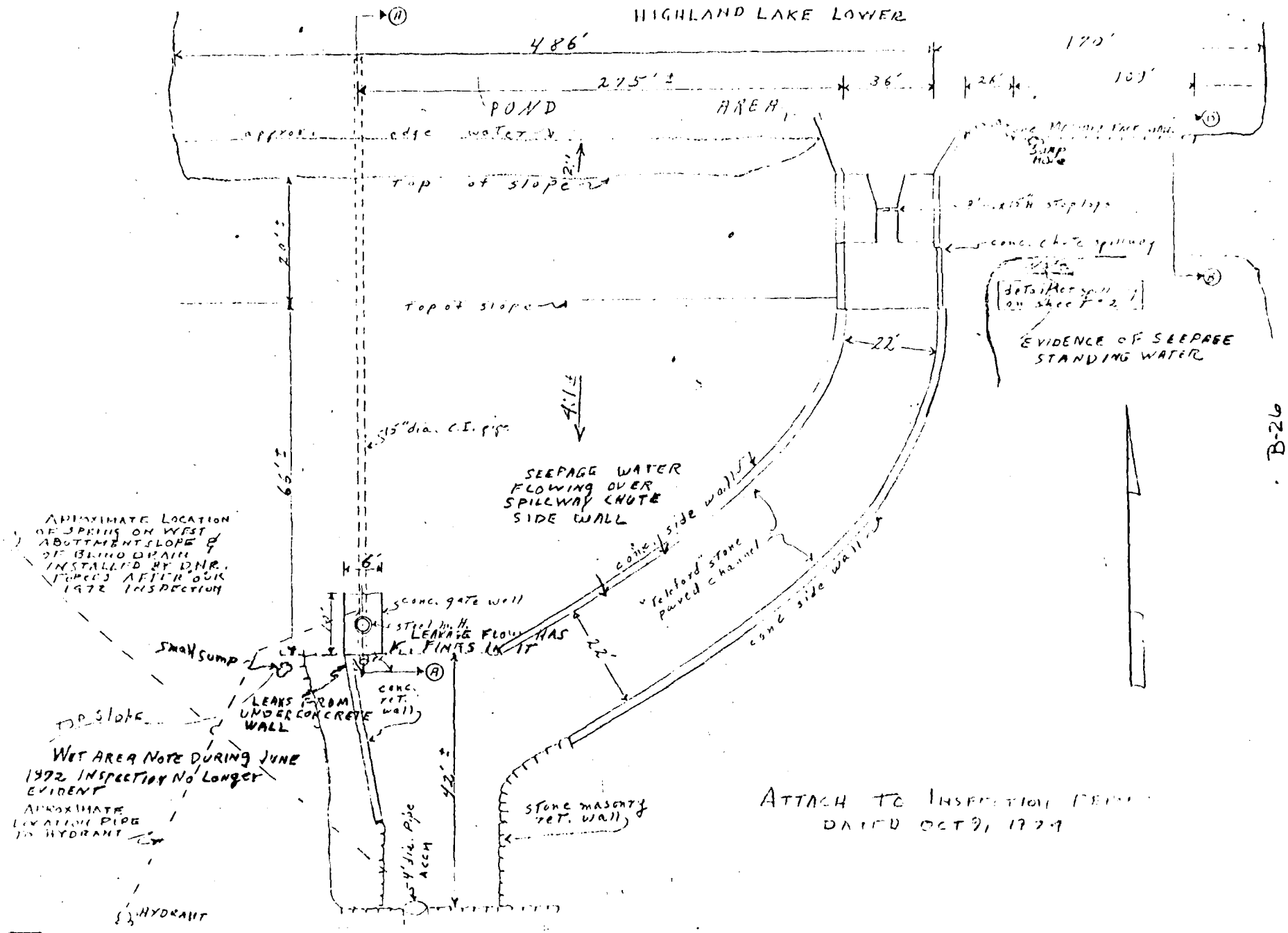
Locus Plan

Sketches

Urban or developed areas are 5 miles downstream in Williamsburg and 8 miles downstream in Northampton.

SKETCH NOT TO SCALE
SHEET NO. 1 OF 2 SHEETS

HIGHLAND LAKES LOWER DAM
DAM NO. 2-8-1

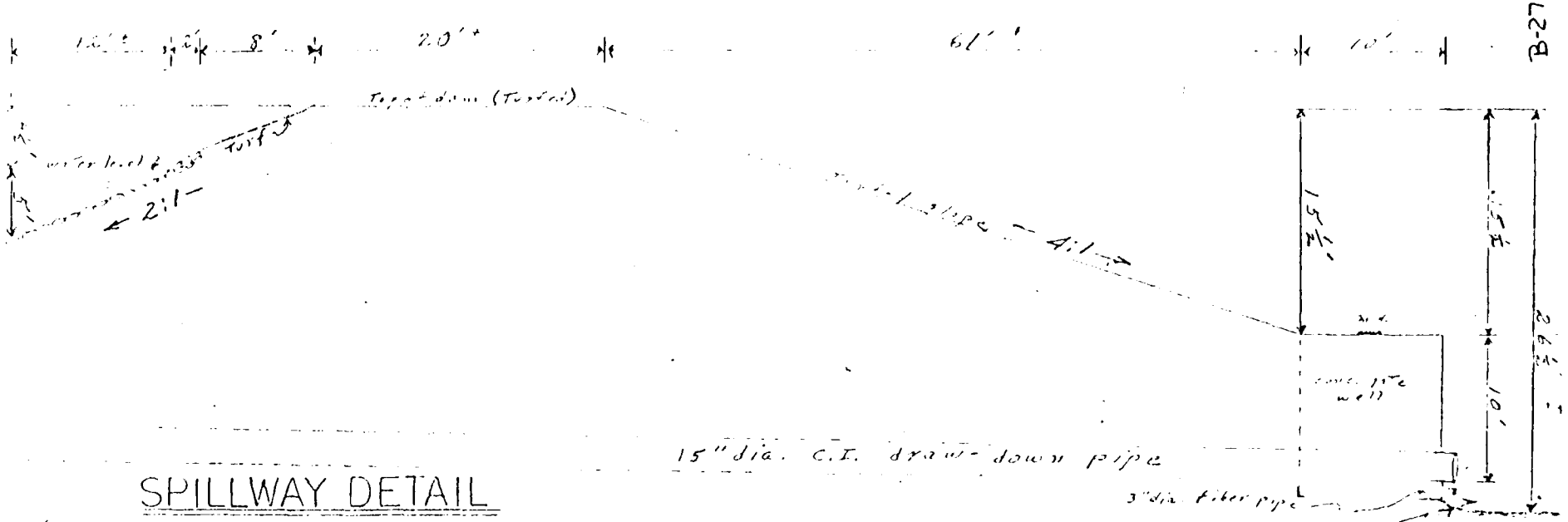


ATTACH TO INSPECTION REPORT DATED OCT 9, 1979

SHEET NO. 2 OF 2 SHEETS

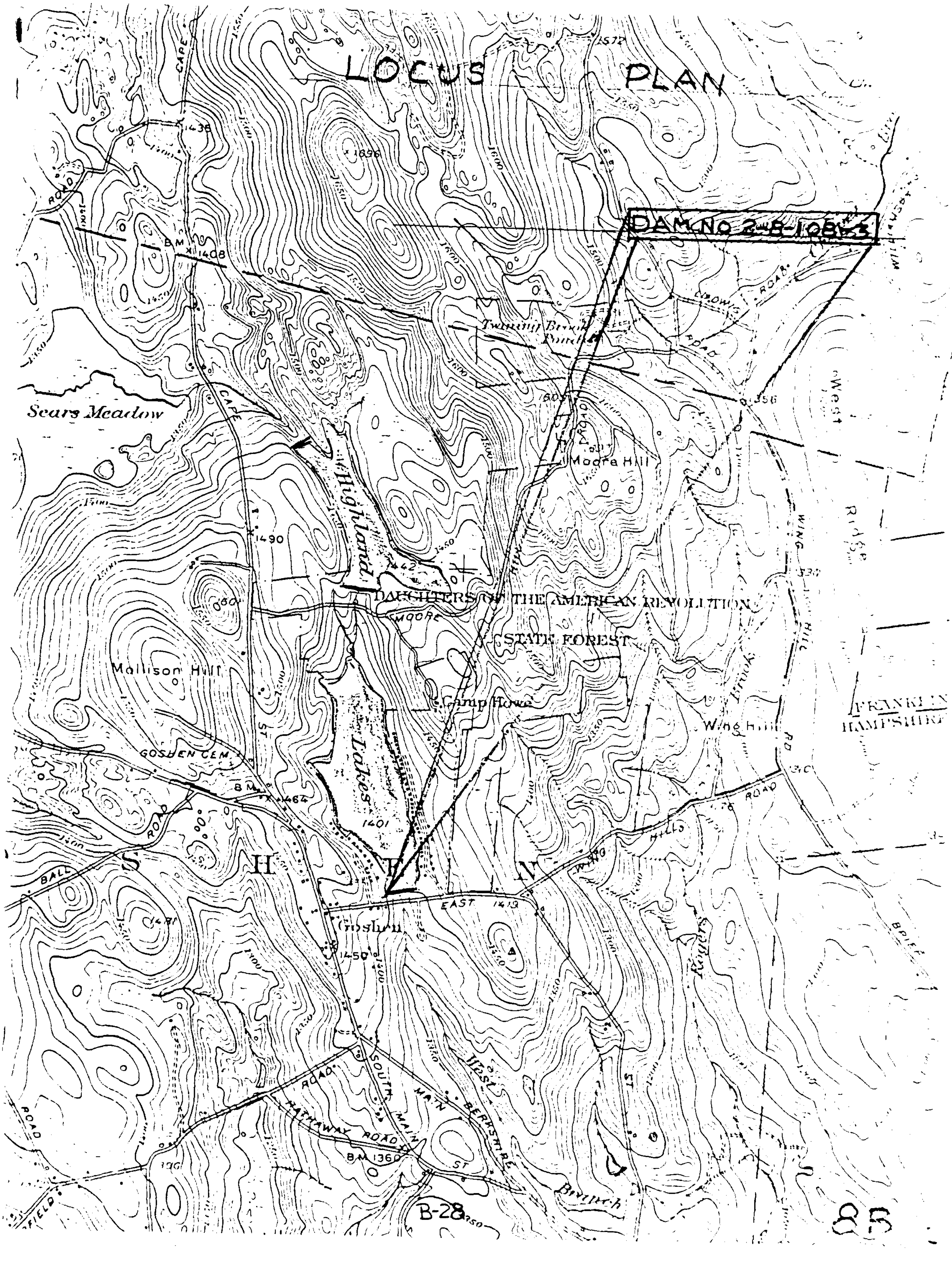
DAM No. 2-2

X-SECTION A-A



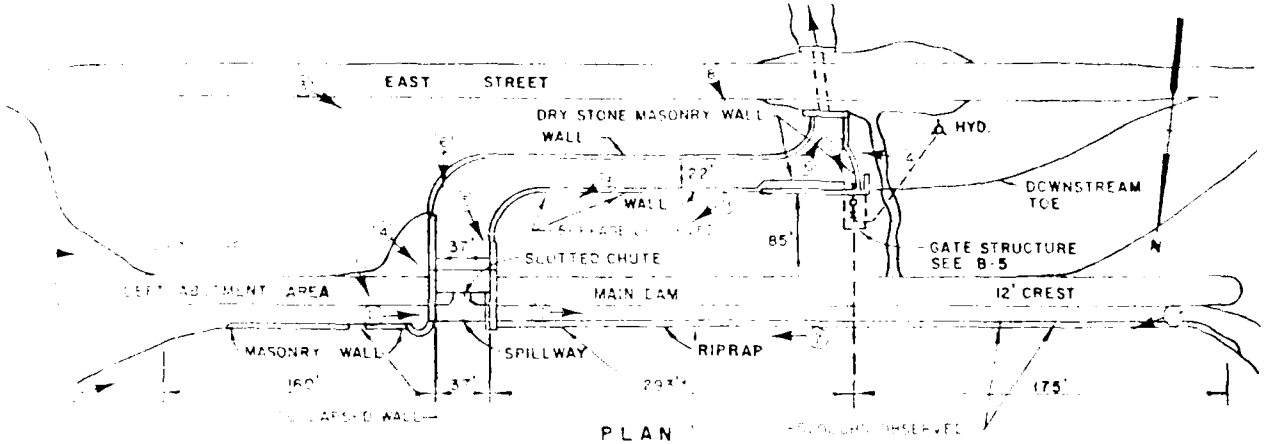
SPILLWAY DETAIL

X-SECTION B-B


LOCUS PLAN
DAM NO 2-8-108-3
Twining Brook Pond
Sears Meadow
Highland Lakes
Moore Hill
Mallison Hill
DAUGHTERS OF THE AMERICAN REVOLUTION STATE FOREST
Camp Howe
Wing Hill
West Ridge
FRANKLIN
HAMPSHIRE
Goshen
GOSHEN CEM.
B-28

APPENDIX C

PHOTOGRAPHS



PLAN

HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

HIGHLAND LAKES - LOWER LAKE DAM
PHOTO LOCATIONS

GOSHEN

PHOTO NO. 1 - Lower Highland Lake viewed from left abutment area.

PHOTO NO. 2 - Dam from left abutment.

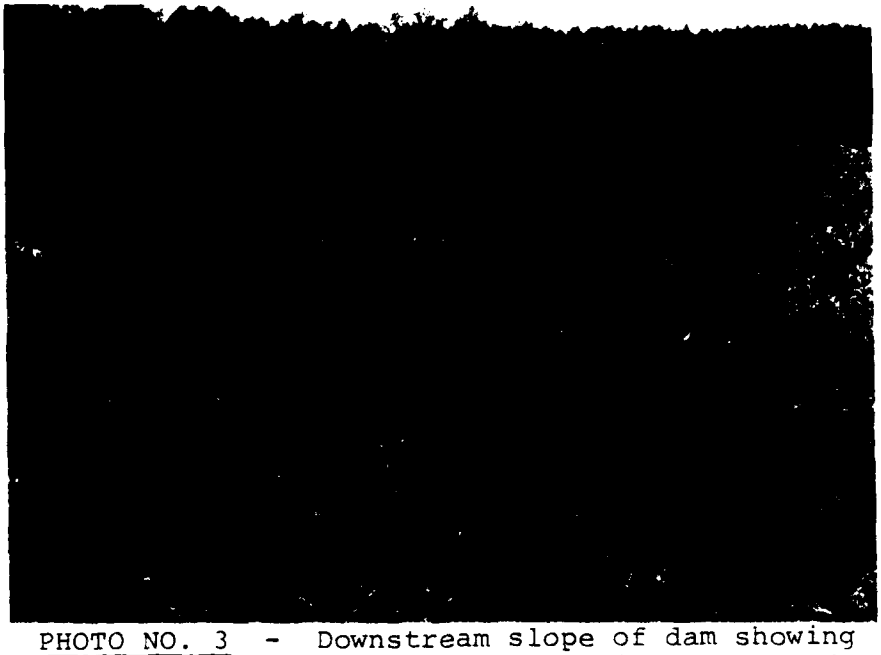


PHOTO NO. 3 - Downstream slope of dam showing spillway channel in foreground.

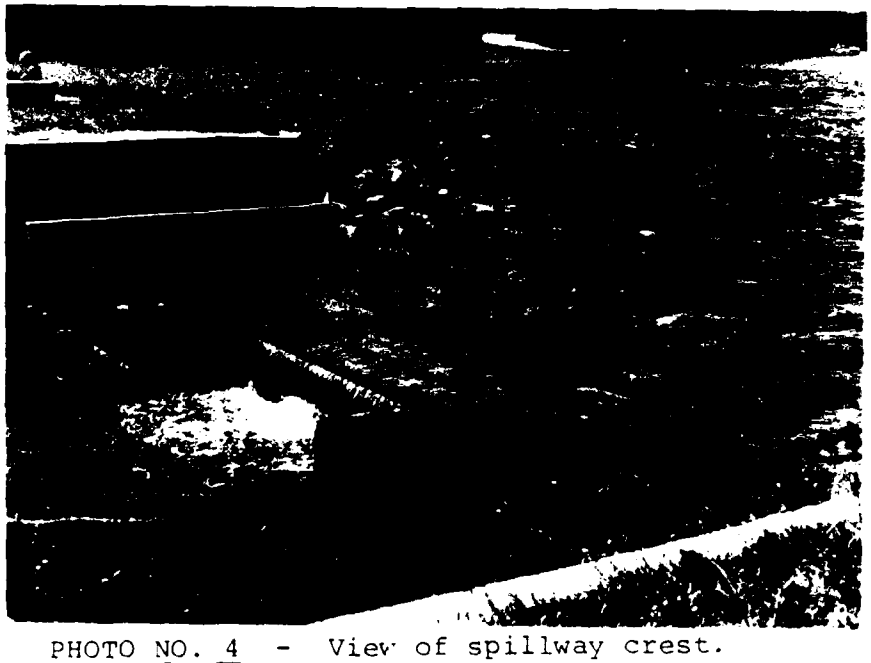


PHOTO NO. 4 - View of spillway crest.

PHOTO NO. 5 - Outlet pipes and headwall at downstream toe.

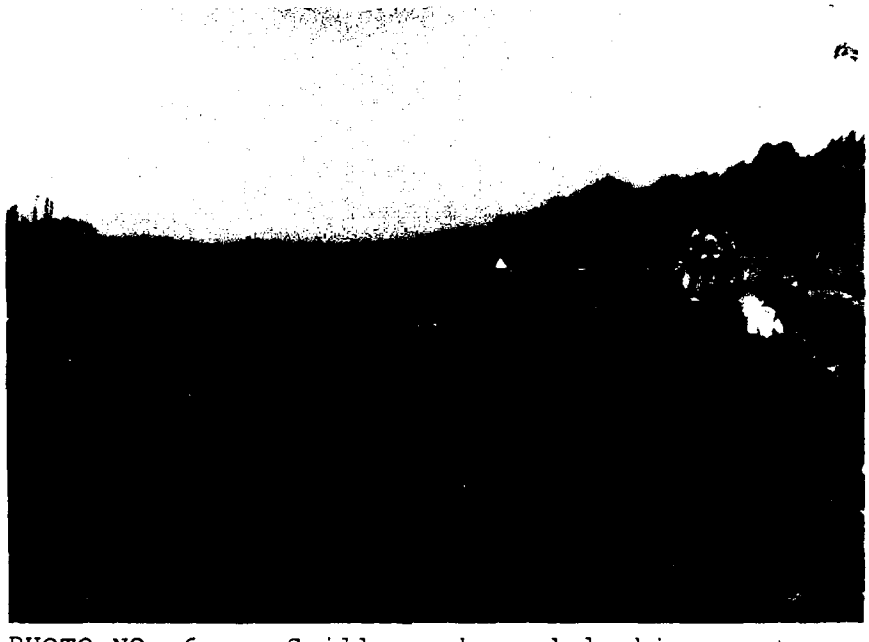


PHOTO NO. 6 - Spillway channel looking upstream.

PHOTO NO. 7 - Riprap on upstream slope.

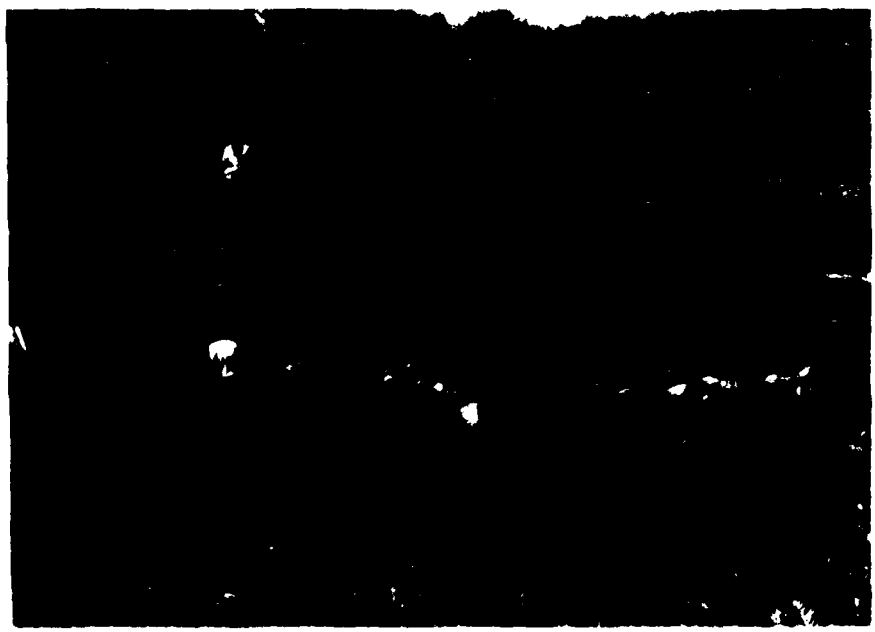


PHOTO NO. 8 - Outlet structure at toe of dam. Outlet pipe is at bottom of concrete section of headwall.

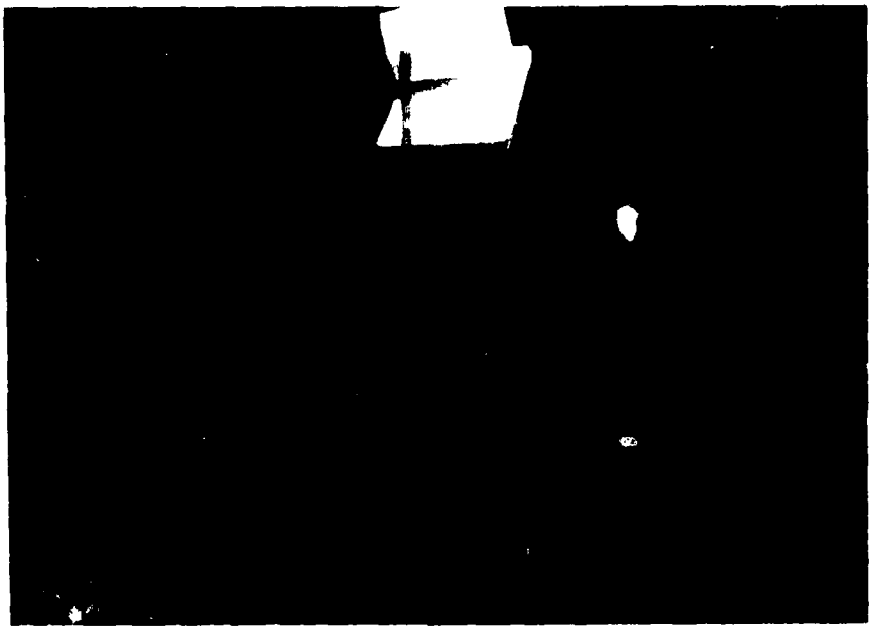


PHOTO NO. 9 - Hole on upstream slope about 4 feet above water near center of dam.

PHOTO NO. 10 - Upstream riprap showing collapsed area near center of dam.

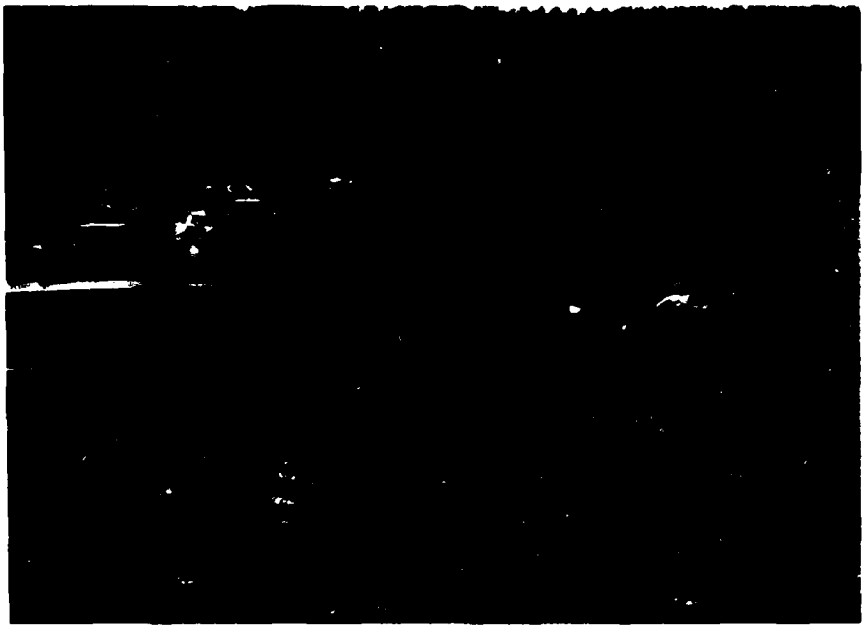


PHOTO NO. 11 - Riprap collapse near right training wall of spillway.

PHOTO NO. 12 - Masonry wall on upstream slope left of spillway showing collapsed area near center.

PHOTO NO. 13 - Area of seepage near downstream toe about 35 feet from right training wall of spillway.

PHOTO NO. 14 - Spillway outlet channel along toe of dam.

PHOTO NO. 15 - View of spalled concrete at right spillway training wall.

PHOTO NO. 16 - Corrugated metal culvert under roadway embankment downstream of dam.

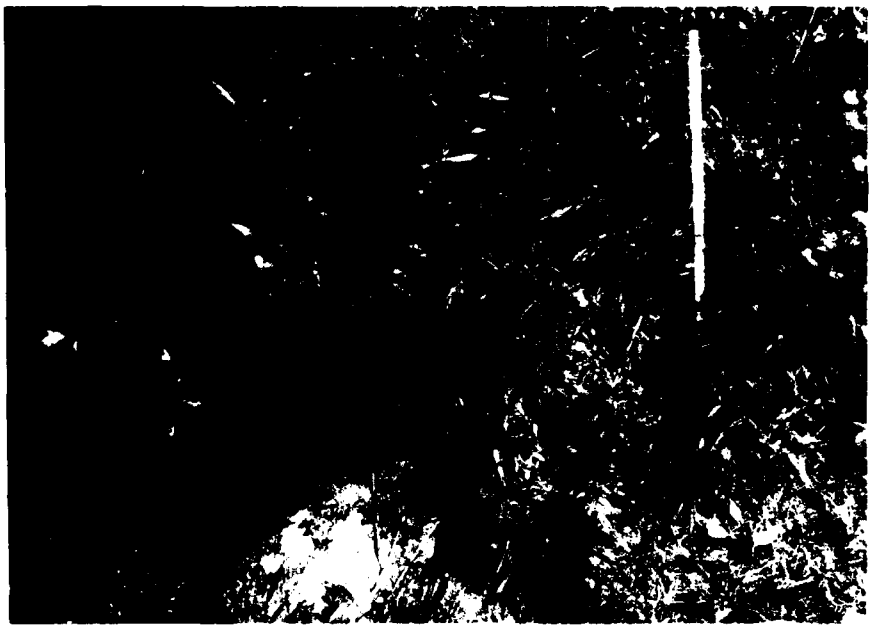


PHOTO NO. 17 - One of several small sloughs and holes in upstream slope about 50 feet from right abutment.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

JOB NO. 79206.1001
DATE 8-17-81
BY MJA
CHK'D BY J. FERRISS

HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

SHEET NO
JOB Dams
SUBJECT Highland
CLIENT COE

Highland Lakes Lower Reservoir

Goshen, Mass.

Dam Size Intermediate (Corps Guidelines)

26 1/2 ft. hydraulic height (small)
1750 a-ft storage (intermediate)

Earth Embankment

Hazard Potential High (potential loss of up to 10 lives

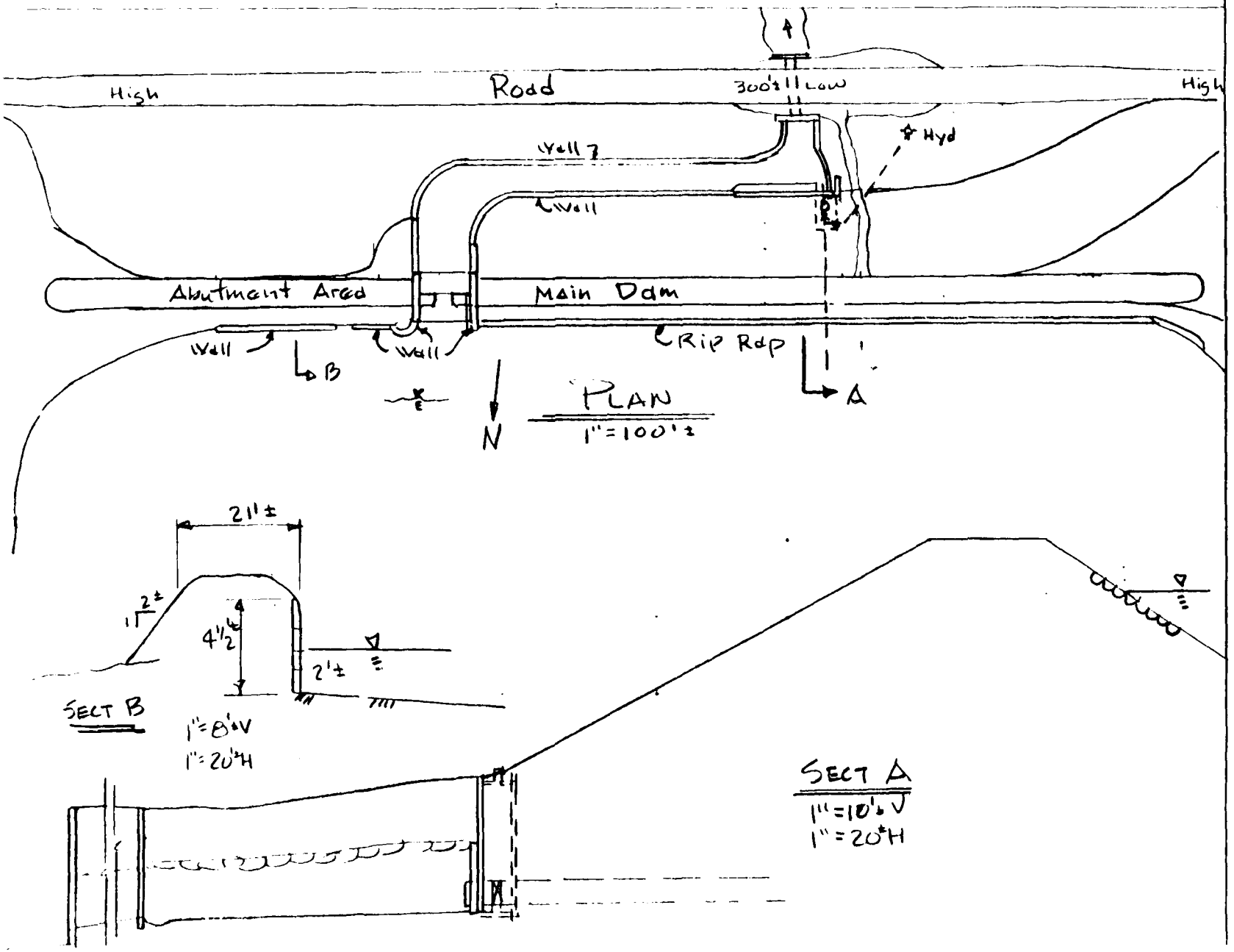
13 ± homes impacted by dam failure
Flooding 6 to 14 ft. depth, above first flor
initial outflow = 27,523 ± cfs

Test Flood full PMF Inflow = 3330. cfs
From 528 acre drainage area
plus outflow from upper lake.

The spillway has provisions for 1 1/2 ± x 8'
of flashboards which are not
significant to its capacity.

Routed outflow = 1430 cfs at
elev 1403.8 spillway area can
pass 775 ± cfs, remainder over tops
Left abutment area (top elev 1403.)
by 0.8 ft, flow ≈ 655 cfs.

Main dam section, top elev. 1404 is
not overtopped.



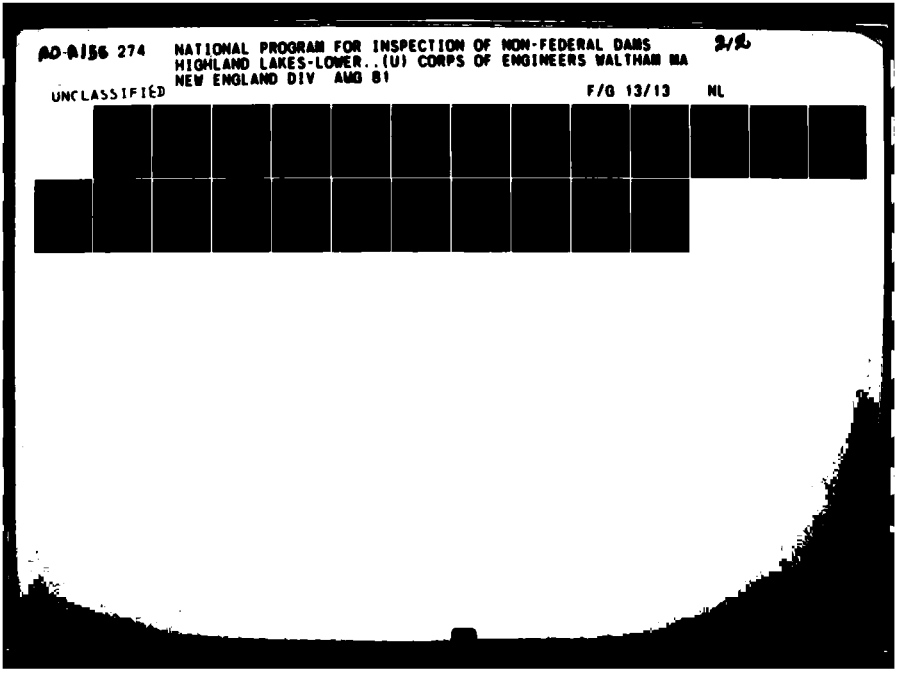
JOB NO. 79206.1001
DATE 8-10-81
BY WJA
CH'D BY FERRIS

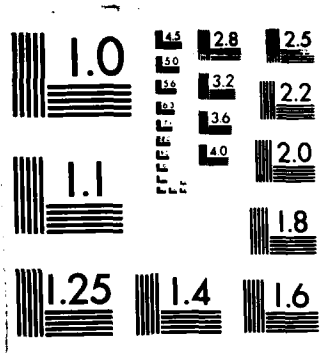
HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

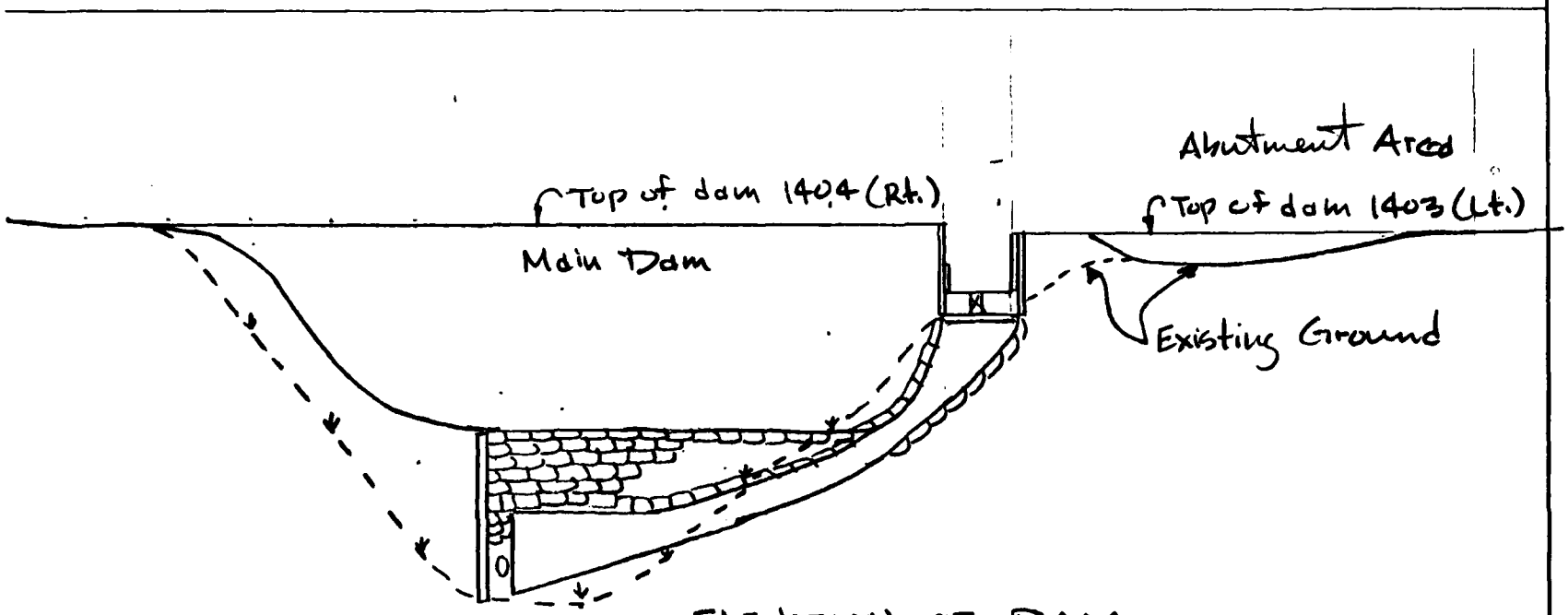
SHEET NO. 1-3
JOB Dams
SUBJECT Highland - Lower
CLIENT CDE

AD-A156 274 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS HIGHLAND LAKES-LOWER..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV AUG 81 2/2

UNCLASSIFIED F/G 13/13 NL







ELEVATION OF DAM

----- Existing top of dam (prior to 1936) of verticle d.s. masonry dam before 1936 reconstruction

JOB NO. 79206.001
DATE 8-11-81
BY MJQ
CH'D BY J. FERRISS

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

JOB Dams
SUBJECT Hydrology
CLIENT COE

SHEET NO. 2-1

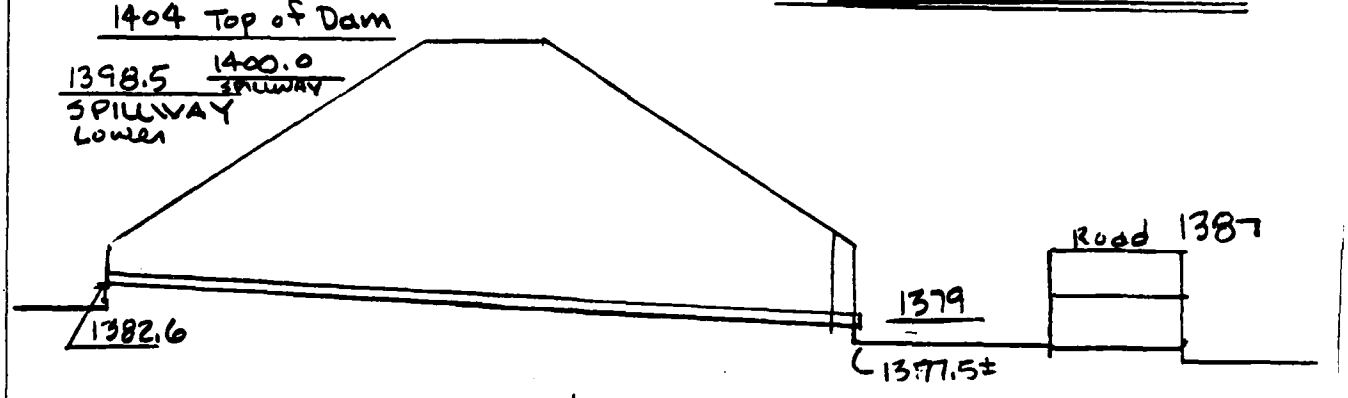
JOB NO. 79206.1001
DATE 8-11-81
BY MJA
CH'D BY J. FERRIS

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

SHEET NO. D-5
JOB Dams
SUBJECT High Hazard Potential
CLIENT CoE

DAM FAILURE ANALYSIS

"High Hazard Potential"



Hydraulic Height = 26½ ± Ft.
Length At Mid Height ≈ 300 Ft.

Failure Discharge

$$Q_{FW} = \frac{8}{27}(0.4 \times 300\,Ft)\sqrt{32.2}\,(26\tfrac{1}{2})^{3/2} = 27{,}523.\ cfs$$

(201.76, 1304)

"wet weather failure"

$$Q_{FD} = \frac{8}{27}(0.4 \times 300)\sqrt{32.2}\,(22\tfrac{1}{2})^{3/2} = 21{,}533.\ cfs$$

"dry weather failure"

From Sta 0+00 to 185+00 ± no homes are located near the stream channel.
From Sta 185+00 to 240+00 ± about 13 homes are built along the stream channel. Spillway discharge prior to Failure (1600 ± cfs) and a base flow of 500 ± cfs (Geo. Sur. Cir. 377 73 ± cfs/sm Mar, 1951) would cause a flood stage of 7' ±, elev. 680 ±. Total flood stage ≈ 15.3' ±, elev. 690.3 Sta 240+00 ± Base Flow impacts 8 homes D ≈ 6', Failure flow 5 homes by 6 to 10" (no base flow flooding), 8 homes by additional eight' ± above base flow conditions.

TEST FLOOD ANALYSIS

Size Class

Hydraulic height = 26 1/2 ± ft. "small"
Storage Capacity = 1750 ± a-f "Intermediate"

Size Class = Intermediate

Hazard Potential (High)

Failure Analysis indicates 13 homes impacted by dam failure floodwater 6 to 14 ± ft. deep.

TEST Flood Inflow

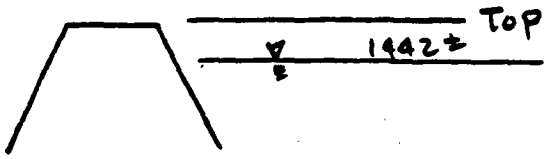
A) Drainage Area to Upper Dam is 575 acres (0.9 s.m.)

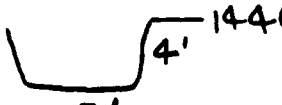
B) Drainage Area (direct) to lower Dam is 528 a (0.82 s.m.)

TEST FLOOD Inflow is full PMF

Upper Dam

Inflow = $0.9_{sm} \times 3000$ cfs/sm = 2700 cfs (19" runoff)



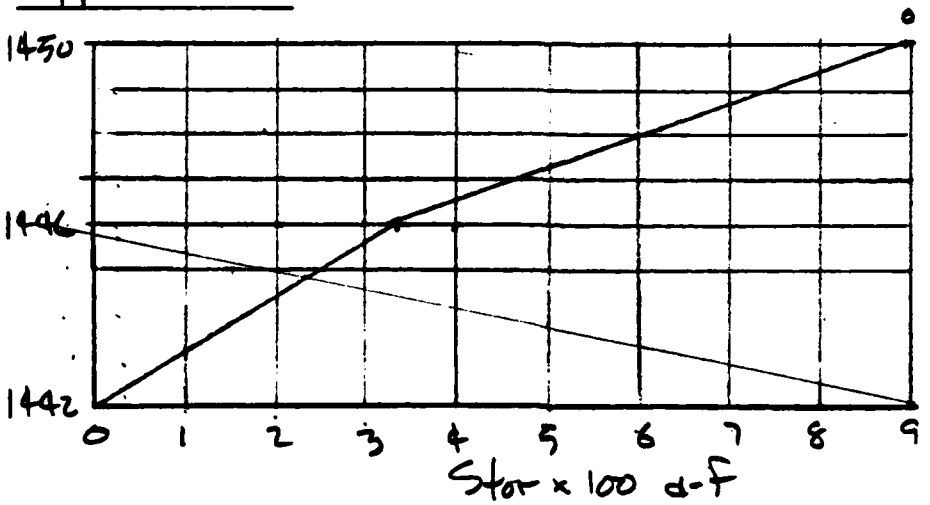
Outlet channels 2 

Q = 1900 cfs

$V = \frac{1.486}{.103}\left(\frac{60}{23}\right)^{2/3}(0.03)^{1/2} =$ 16 fps $Q = 2(16)(60) = 1900^{\pm}$ cfs

Test Flood

Upper Dam



Overflow "Dam + Dike" $Q = CLH^{3/2}$

D	C	$H^{3/2}$	L	Q	Elev	Q_I
1/2	2.63	.35	800	736	1446.5	2636

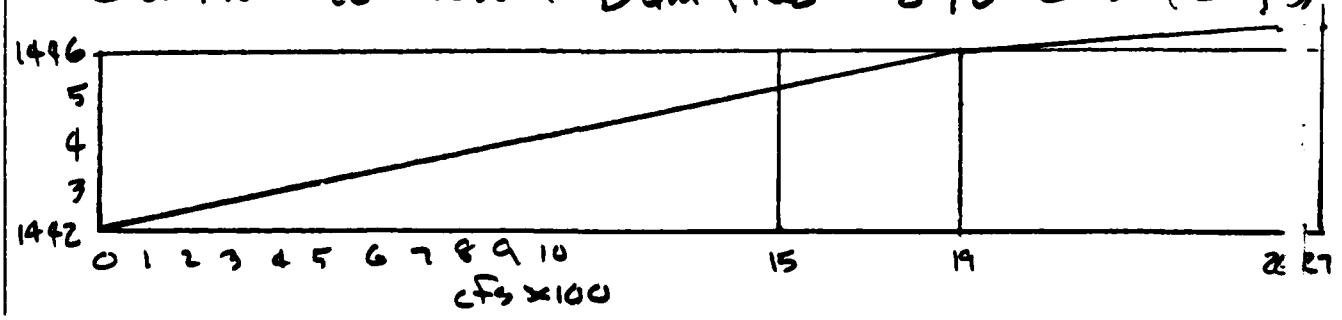
$Q_{P_2} = 2700\left(1 - \frac{8.33}{19}\right) = 1,515$ cfs ✓

[$Q_{P_1} = 2700$, $D_1 = 1446.5\pm$ $Stor_1 = 400$ a-f $= \frac{400 \times 12}{575} = 8.33''$] ✓

$D_2 = 1445\pm$ $Stor_2 = 250$ a-f $= 5.2''$ ave $= 6.8''$ ✓

$Q_{P_3} = 2700\left(1 - \frac{6.8}{19}\right) = 1738$ ✓ cfs (two outlets)

Outflow to Lower Dam & Res $= 870\pm$ cfs $(\frac{1}{2}Q_{P_3})$



TEST FLOOD

Lower Dam Inflow

Inflow = 870 cfs + (0.82 sm × 3000 $\frac{cfs}{sm}$) = 3,330. cfs.

Q_{P_1} = 3330 cfs D_1 = 1404.75 ✓

$Stor_1$ = 535 af = 12.15" ✓ $\left(\frac{535 \times 12}{528}\right)$

$Q_{P_2} = 3330\left(1 - \frac{12.15}{19}\right) = 1199$ cfs ✓ $\left(\frac{420 \times 12}{528}\right)$

D_2 = 1403.6 ✓ $St_2 = 420_{af} \equiv 9.5"$ ave = 10.85' ✓

$Q_{P_3} = 3330\left(1 - \frac{10.85}{19}\right) = 1430 \pm$ cfs ✓

Elev = 1403.8 ✓

Main Dam is not overtopped

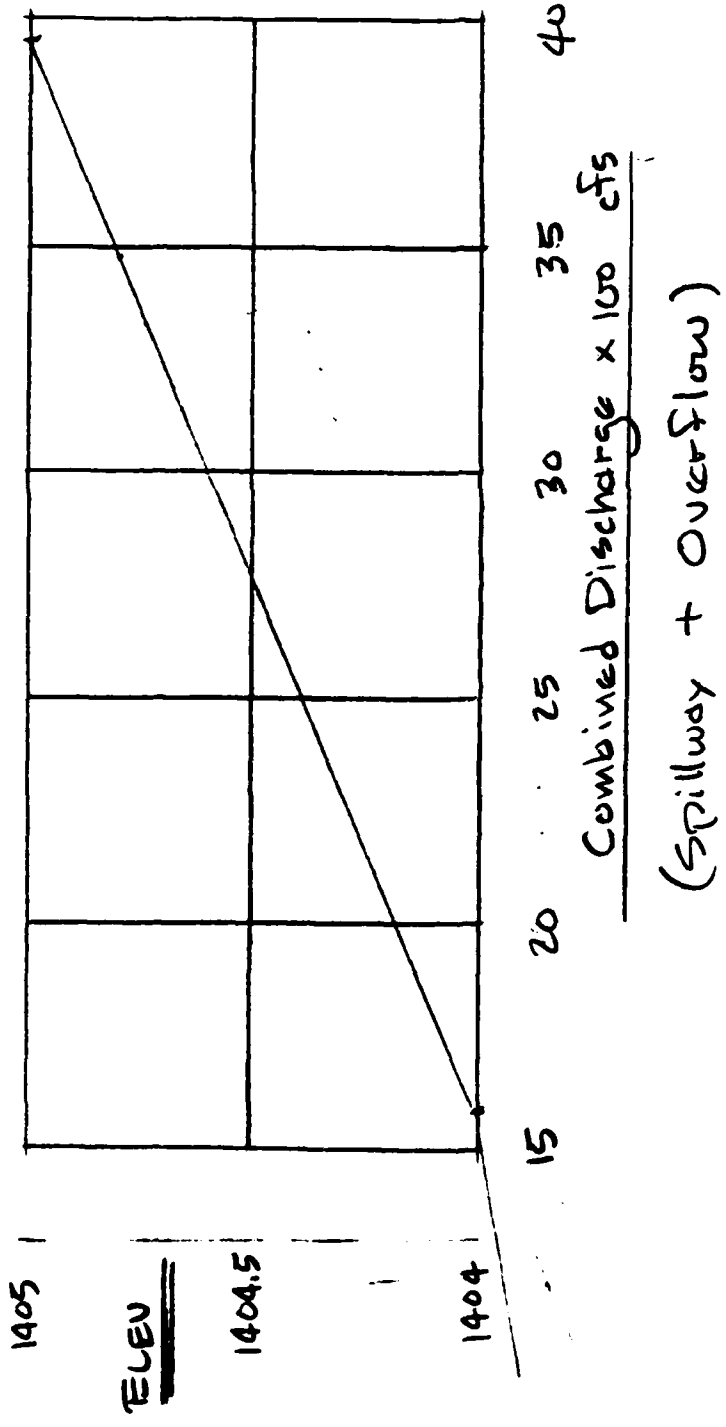
Left "Dam/Abutment area"

is overtopped by 0.8 ft. ✓

JOB NO. 79206.1001
DATE 8-17-81
BY MJA
CH'D BY J. Ferreira

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

SHEET NO. D-9
JOB Dams
SUBJECT Highland
CLIENT COE

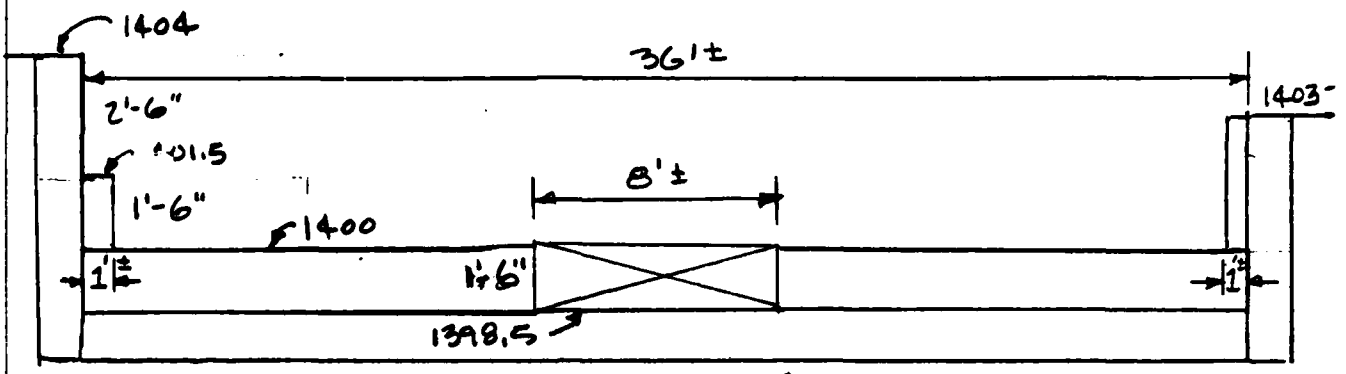


JOB NO. 79206.1001
DATE 8-10-81
BY MJA
CH'D BY J. Ferriss

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

SHEET NO. D-12
JOB Dams
SUBJECT Highland - Lower
CLIENT COE

Spillway Discharge



Broad Crested $Q = CLH^{3/2}$

D	C	L	$H^{3/2}$	Q cfs	ELEV	
0.5	2.7	8'	0.35	7.6 ✓	1399	} 8'x1.5' channel
1.0	2.68	8'	1.0	21.4 ✓	1399.5	
1.5	2.65	8'	1.84	39.- ✓	1400	
				cfs		Q_{Total}
0.5	2.7	35	0.35	33 ✓	1400.5	72 cfs ✓
1.0	2.68	35	1.0	94 ✓	1401.0	133 ✓
1.5	2.65	35	1.84	171. ✓	1401.5	210 ✓
2.0	2.64	36	2.83	269. ✓	1402.0	308 ✓
3.0	"	"	5.2	494. ✓	1403.	533 ✓
4.0	"	"	8.	760. ✓	1404.	799 ✓
5.0	"	"	11.18	1063. ✓	1405	1102 ✓
6.0	"	"	14.7	1397 ✓	1406	1436 ✓

$Q'_{Town.}$
1588
3955
+

Dam Overflow

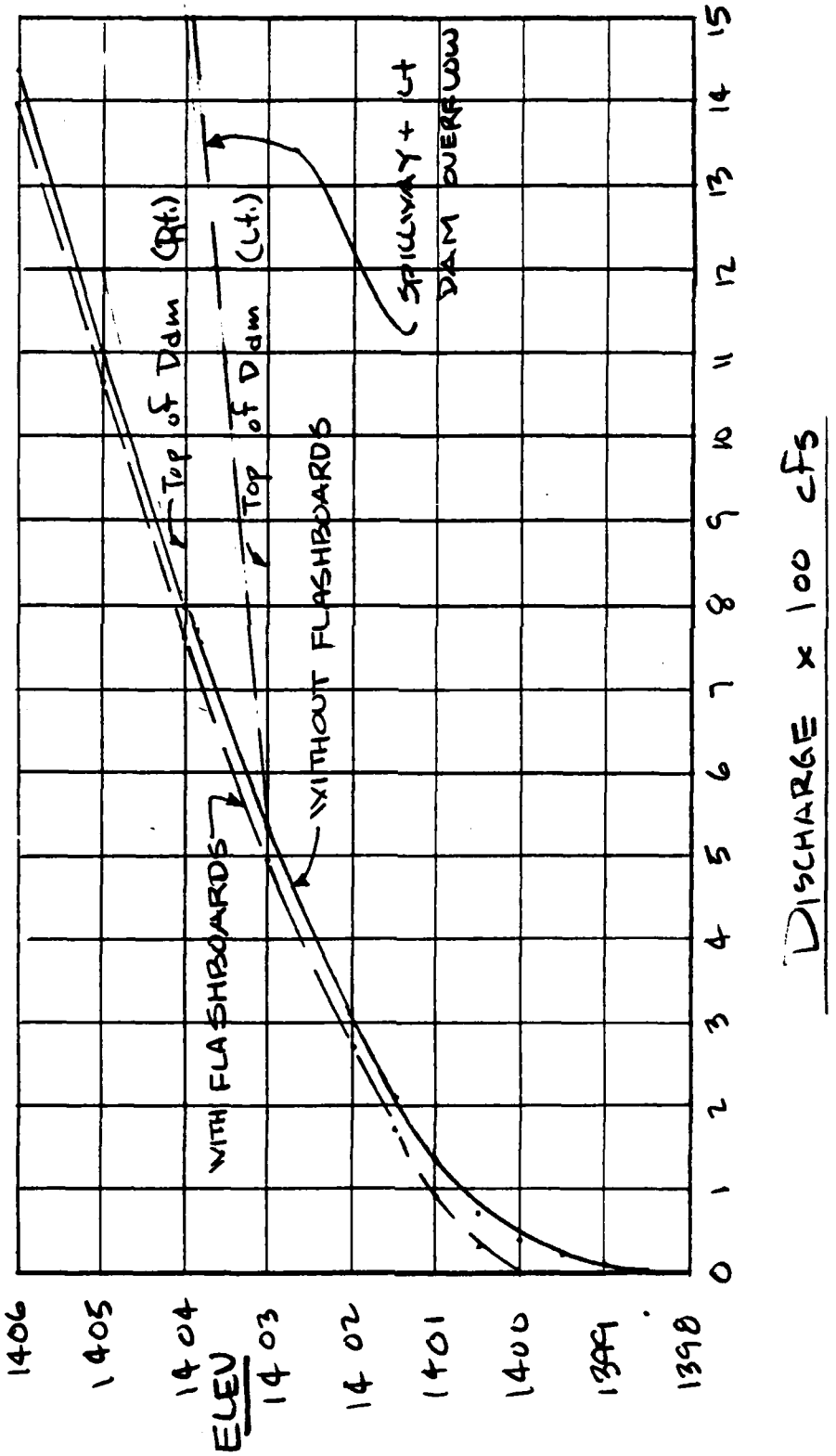
D	C	L	$H^{3/2}$	Q	Elev	Q_T
1	2.63	300	1	789	1404	1588 ✓
1	3.17	900	1	2853	1405	3955 ✓

JOB NO. 792061001
DATE 8-10-81
BY MJA
CH'D BY J. FERRISS

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

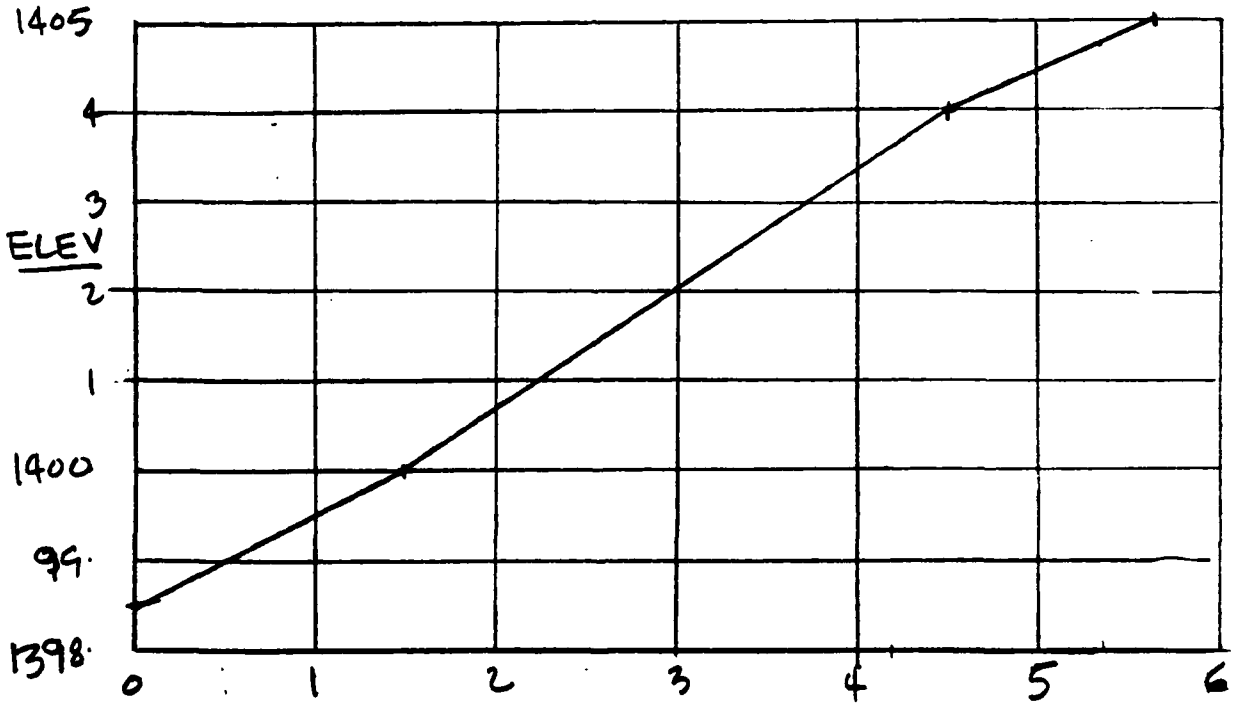
SHEET NO. D-11
JOB Dams
SUBJECT HIGHLAND LOWER
CLIENT COE

SPILLWAY DISCHARGE



Storage Capacity

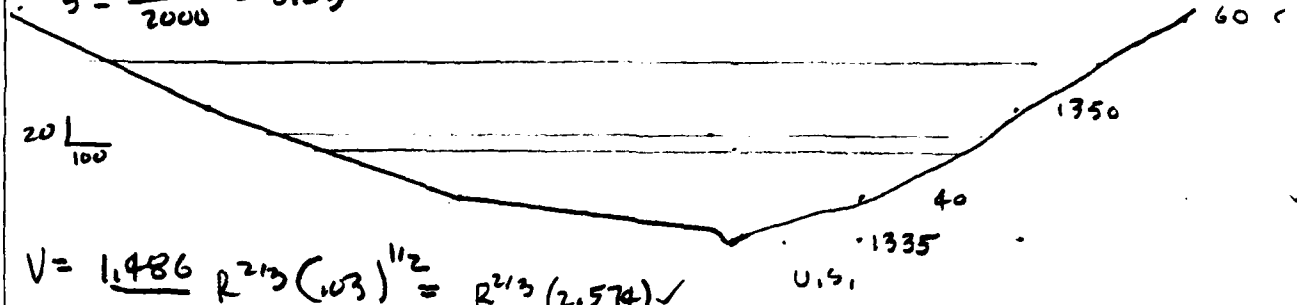
ELEV.	AREA	AREA AVE	D	Vol d-f	Accum Vol A-f	
1410	125	112.5	10	1125. ✓	2475.	565
1404	Top of dam				1750	450
1400	100	83	10	830 ✓	1,350. ✓	150
1398.5	spillway	crest			680	0
1390	66	52	10	520 ✓	520.	
1380	37	0	—	—	—	



Storage Capacity x 100 a-f

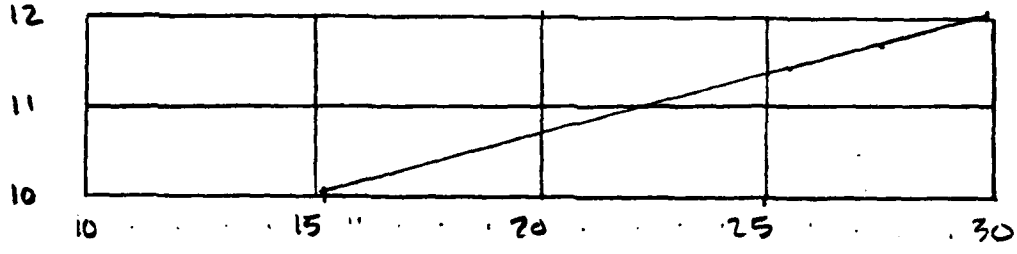
Sta 20+00

$S = \frac{60}{2000} = 0.03$



$V = \frac{1.486}{0.10} R^{2/3} (.03)^{1/2} = R^{2/3} (2.574)$ ✓

D	WP	A	$R^{2/3}$	2.574	V	Q
10	350	1900	3.11 ✓	"	8. ✓	15,192. ✓
15	450	4240	4.5 ✓	"	11.57 ✓	49,052 ✓
20	550	6740	5.36 ✓	"	13.8 ✓	92,988 ✓
12	390	2980	3.9 ✓	"	10. ✓	29,960. ✓



$Q_{P_1} = 27,523.$ cfs $D_1 = 11.75$ $A = 2880$ $V_1 = \frac{2880 \times 2000}{43560} = 137.$ ✓ a-f

$Q_{P_2} = 27523 \left(1 - \frac{132}{1750}\right) = 25447.$ ✓ $D_2 = 11.4$ ✓

$V_2 = 2746 \times 2000 \times \frac{1}{43560} = 126.$ a-f ✓

$Q_{P_3} = 27523 \left(1 - \frac{129}{1750}\right) = 25494.$ ✓ cfs Elev 11.45

Elev = 1346.45 ✓

JOB NO. 7206 1001
DATE 8-11-81
BY MJA
CHK'D BY J. Ferris

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

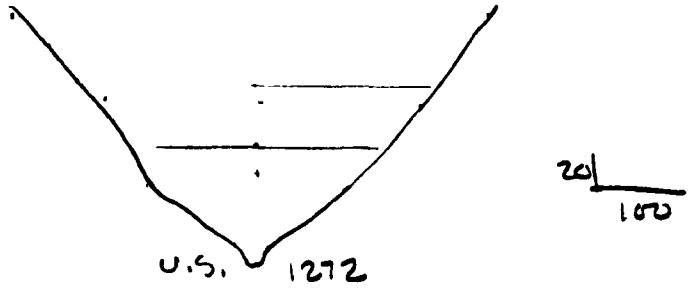
SHEET NO. D-14
JOB Dams
SUBJECT Highland
CLIENT COE

Sta 40+00

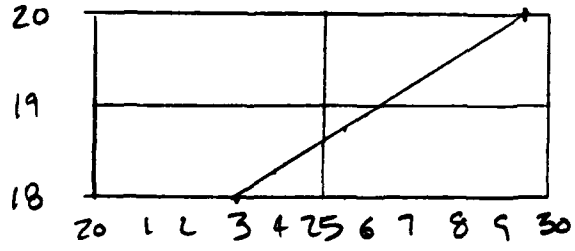
$S = \frac{68}{2000} = 0.034$ ✓

$V = R^{2/3}\left(\frac{1.486}{0.10} \times .034^{1/2}\right)$

$= R^{2/3}\ (2.74)$ ✓



D	WP	A	$R^{2/3}$ "2.74"	V	Q
13	145	1020	3.7 ✓	"	10.125 ✓ 10327. ✓
18	185	1820	4.63 ✓	"	12.68 ✓ 23,070. ✓
20	205	2200	4.9 ✓	"	13.44 ✓ 29,561 ✓



$Q_{P_1} = 25494.$ $D_1 = 18.75$ ✓ $V_1 = \frac{1959 + 2800}{2}(.0459) = 109$ ✓

$Q_{P_2} = 25494\left(1 - \frac{109}{1750}\right) = 23,903.$ ✓ $D_2 = 18.25$ ✓

$V_2 = \frac{1820 + 2800}{2}(\quad) = 107$ ✓ $V_a = 108$ ✓

$Q_{P_3} = 25494\left(1 - \frac{108}{1750}\right) = 23,921.$ ✓ cfs $D_3 = 18.25$ ✓

$El_w = 1290.25$ ✓

JOB NO. 79206.1001
DATE 8-11-81
BY WA
CH'D BY J. FERRISS

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

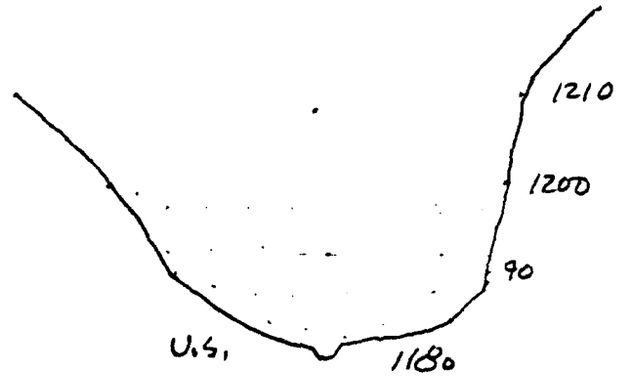
JOB Dams SHEET NO. 7-15
SUBJECT Highland
CLIENT COE

Sta 65+00

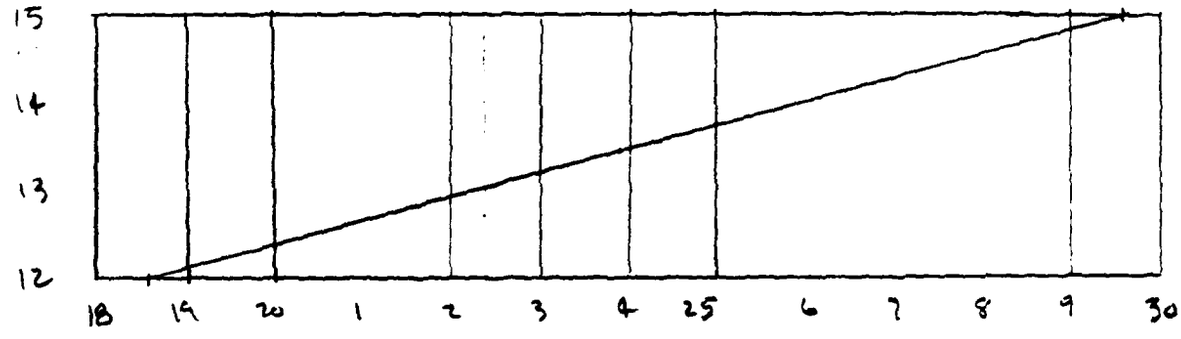
$S = \frac{65}{2000} = 0.0325$ ✓

$V = \frac{1.486}{0.10} R^{2/3} (.0325)^{1/2}$

$= R^{2/3} (2.679)$ ✓



D	WP	A	$R^{2/3}$	( )	V	Q
10	185	1130	3.361 ✓	2.629 ✓	9, ✓	10176, ✓
15	200	2210	5. – ✓	"	13.4 ✓	29608 ✓
20	235	3270	5.84 ✓	"	15.6'	51127 ✓
12	190	1640	4.2 ✓	"	11.35 ✓	18,621 ✓



$Q_{P_1} = 23921$ ✓ $D_1 = 13.4$ ✓ $V_1 = \frac{1906 + 1900}{2} (0.0574) = 109$ ✓ a-f

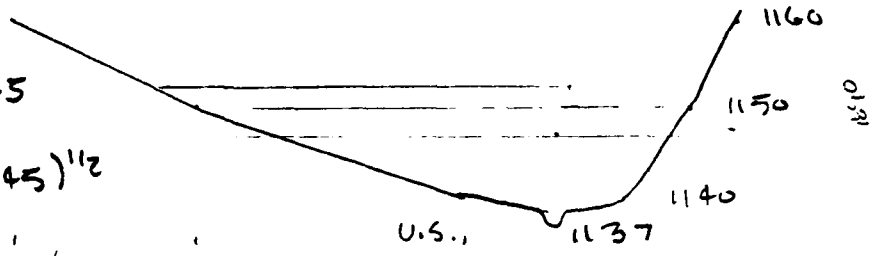
$Q_{P_2} = 23921 \left(1 - \frac{109}{1750}\right) = 22428$ ✓ $D_2 = 13'$ ✓

$V_2 = \frac{1830 + 1900}{2} (\quad) = 107$ ✓ ave = 108 ✓

$Q_{P_3} = 23921 \left(1 - \frac{108}{1750}\right) = 22445$ ✓ $D = 13' \pm$ ✓

Elev = 1193. ✓

Sta 90+00

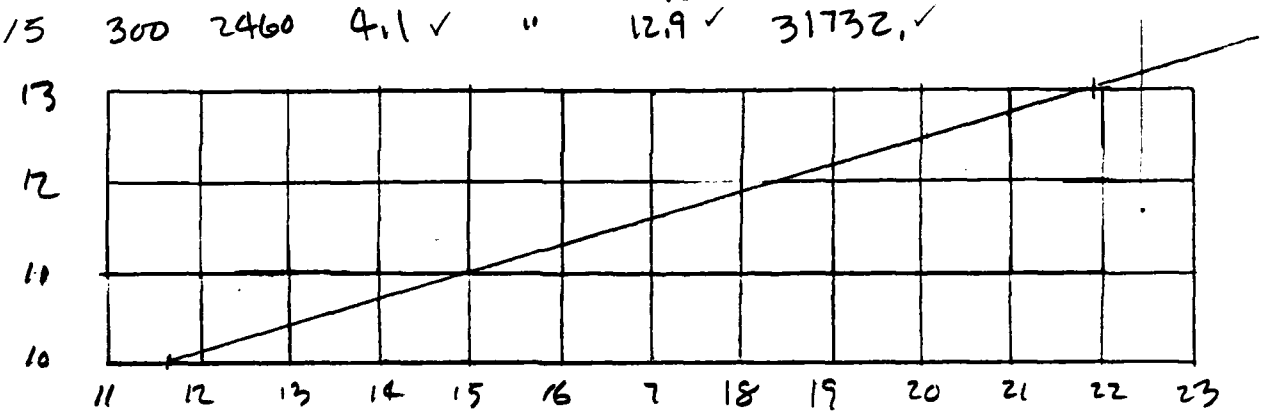


$S = \frac{45}{1000} = 0.045$

$V = \frac{1.486}{n10} R^{2/3} (.045)^{1/2}$

$V = R^{2/3}\ 3.15$ ✓

D	WP	A	$R^{2/3}$	3.15 V	Q
13	270	1890	3.68 ✓	" 11.60 ✓	21927 ✓
10	210	1170	3.16 ✓	" 9.96 ✓	11649 ✓
15	300	2460	4.1 ✓	" 12.9 ✓	31732 ✓



$Q_{P_1} = 22445$ ✓ $D_1 = 13.2$ ✓ $V_1 = \frac{2000+1830}{2}(.0574) = 110$ ✓

$Q_{P_2} = 22445\left(1 - \frac{110}{1750}\right) = 21{,}035$ ✓ $D_2 = 12.75$ ✓

$V_2 = \frac{1830+1830}{2}(\quad) = 105$ ✓ ave = 107.5 ✓

$Q_{P_3} = 22445\left(1 - \frac{107.5}{1750}\right) = 21{,}073 \pm$ cfs

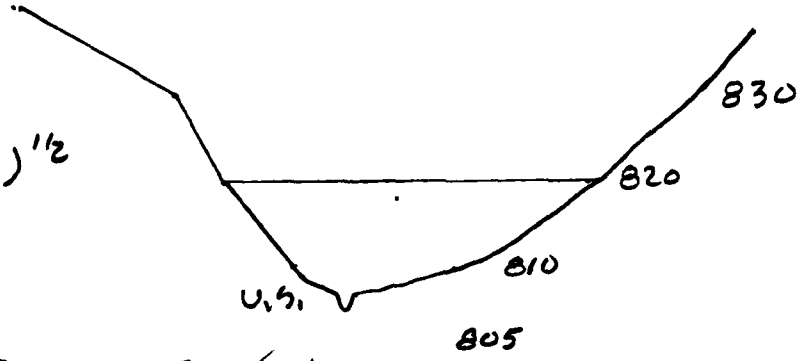
Elev = 1149.75 ✓

JOB NO. 7206.1001
DATE 8-11-81
BY MJA
CH'D BY J. FERRISS

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

SHEET NO. D-13
JOB Dams
SUBJECT Highland
CLIENT COE

Sta 150+00



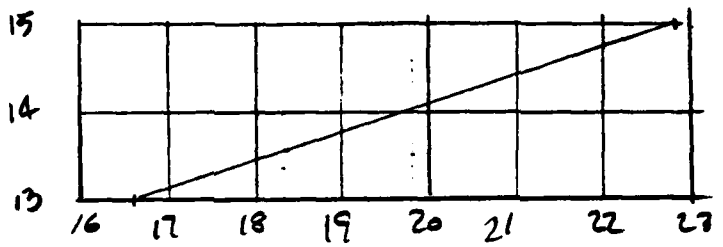
$S = \frac{78}{2000} = 0.039$ ✓

$V = \frac{1.486}{0.10} R^{2/3} (.039)^{1/2}$

$= R^{2/3}\ 2.935$ ✓

D WP a $R^{2/3}$ 2.935 ✓ V Q

15	220	1860	4.18 ✓	"	12.27 ✓	22,818. ✓
13	190	1450	3.90 ✓	"	11.45 ✓	16,608. ✓



$Q_{P_1} = 19845$ ✓ $D_1 = 14'$ ✓ $V_1 = \frac{1605+1790}{2}(0.0803) = 136$ ✓

$Q_{P_2} = 19845\left(1 - \frac{136}{1750}\right) = 18298.$ ✓ $D_2 = 13.6$ ✓

$V_2 = \frac{1573+1790}{2}(\ \ ) = 135$ ave = 135.5

$Q_{P_3} = 19845\left(1 - \frac{135.5}{1750}\right) = 18320.$ ± $D_3 = 13.6$ ✓

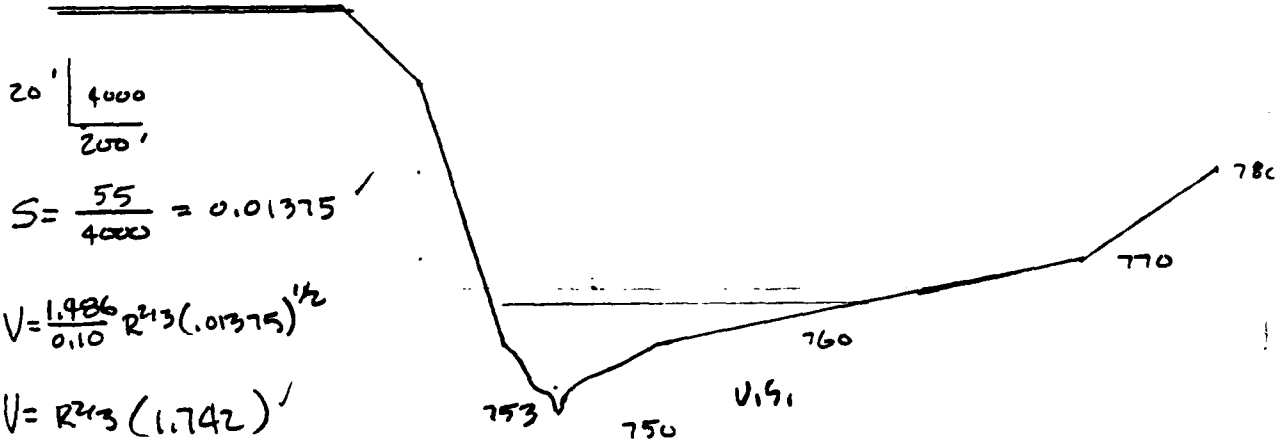
Elev = 818.6 ✓

JOB NO. 79206.1001
DATE 8-12-81
BY MJA
CH'D BY J. Fortuss

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

SHEET NO. D-12
JOB Dams
SUBJECT Highland-Lower
CLIENT COE

Std 180+00

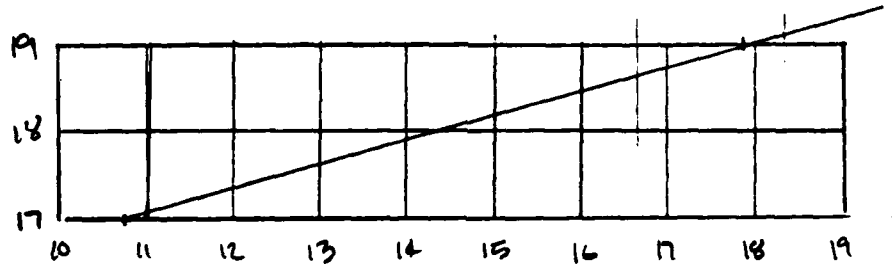


$S = \frac{55}{4000} = 0.01375$ ✓

$V = \frac{1.486}{0.10} R^{2/3} (.01375)^{1/2}$

$V = R^{2/3} (1.742)$ ✓

D	WP	A	$R^{2/3}$	1.742 ✓	V	Q
17	430	2120	2.91 ✓	"	5.07 ✓	10,754 ✓
19	500	3050	3.36 ✓	"	5.85 ✓	17,845 ✓



$Q_{p_1} = 18320$ ✓ $D_1 = 19.1$ $V_1 = \frac{3100 + 1573}{2} \left(\frac{3050}{43560}\right) = 161$ a-f

$Q_{p_2} = 18320 \left(1 - \frac{161}{1750}\right) = 16,650^{\pm}$ $D_2 = 18.65$ ✓

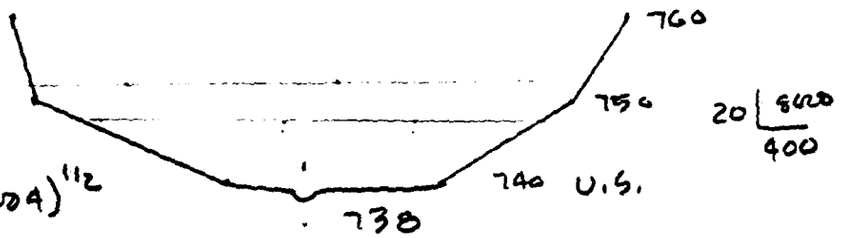
$V_2 = \frac{2904 + 1573}{2} (\quad) = 154$ $V_a = 157.5$

$Q_{p_3} = 18320 \left(1 - \frac{157.5}{1750}\right) = 16,687^{\pm}$ $D_3 = 18.7$ ✓

Elev = 771.7 ✓

Sta 200+00

$S = \frac{10}{2500} = 0.004$

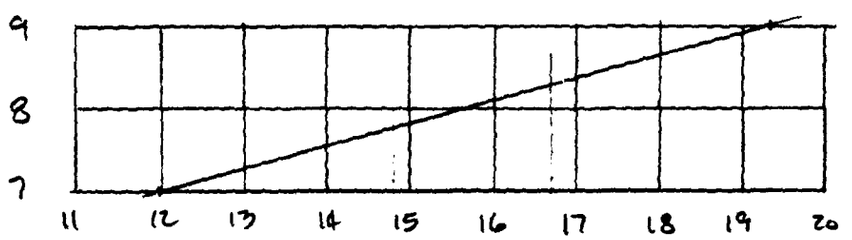


U.S.

$V = \frac{1.486}{0.10} R^{2/3} (.004)^{1/2}$

$V = R^{2/3} (0.94)$ ✓

D	WP	A	$R^{2/3}(.94)$	V	Q
7	900	4400	2.85 ×(.94)	2.72 ✓	11,977. ✓
9	1100	6350	3.24 ✓	3.04 ✓	19,320. ✓



$Q_{R_1} = 16,687.$ cfs $\quad D_1 = 8.3$ ✓ $\quad V_1 = \frac{5670 + 2890}{2}\left(\frac{2000}{43560}\right) = 197$ ✓

$Q_{R_2} = 16687\left(1 - \frac{197}{1750}\right) = 14813$ ✓ $\quad D_2 = 7.8$ ✓

$V_2 = \frac{5180 + 2990}{2}(\quad) = 185$ ✓ $\quad V_1 = 191$ ✓

$Q_{R_3} = 16687\left(1 - \frac{191}{1750}\right) = 14864.$ ✓ $\quad D = 7.8.$

$Elw = 745.8$ ✓

JOB NO. 79206.1001
DATE 5-12-81
BY WJA
CH'D BY J. FERRISS

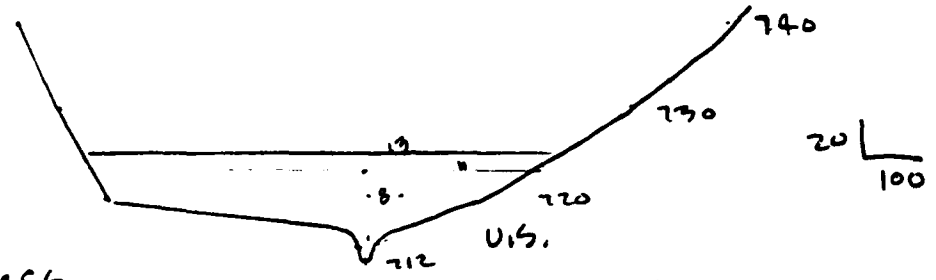
HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON — WEST HARTFORD

SHEET NO. D-21
JOB Dams
SUBJECT Highland-Lower
CLIENT COE

Std 220+00

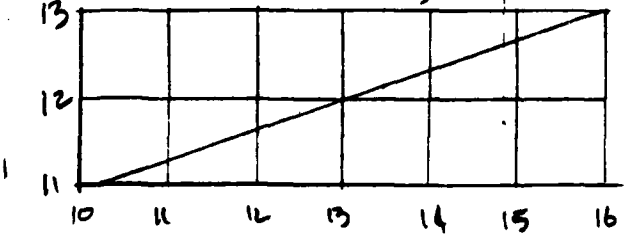
1:2

$S = \frac{40}{2000} = 0.02$



$V = \frac{1.486}{0.10} R^{2/3} (.02)^{1/2} = R^{2/3} (2.1)$ ✓

D	WP	A	$R^{2/3}$	2.1 ✓	V	Q	elev
11	250	1480	3.29 ✓		6.9 ✓	10232. ✓	723
8'	215	790	2.39		5.	3967	720
13	270	2000	3.8 ✓	"	8 ✓	16000. ✓	725
6'	200	350	1.53		3.22	1127.	718



$Q_{P_1} = 14864$ ✓ $D_1 = 12.6$ ✓ $V_1 = \frac{1892 + 5180}{2} \left(\frac{2000}{43560}\right) = 162 \pm$ d-f ✓

$Q_{R_2} = 14864 \left(1 - \frac{162}{1750}\right) = 13{,}485.$ $D_2 = 12.2$ ✓

$V_2 = \frac{1892 + 5180}{2} (\quad) = 160$ ✓ $V_a = 161$ ✓

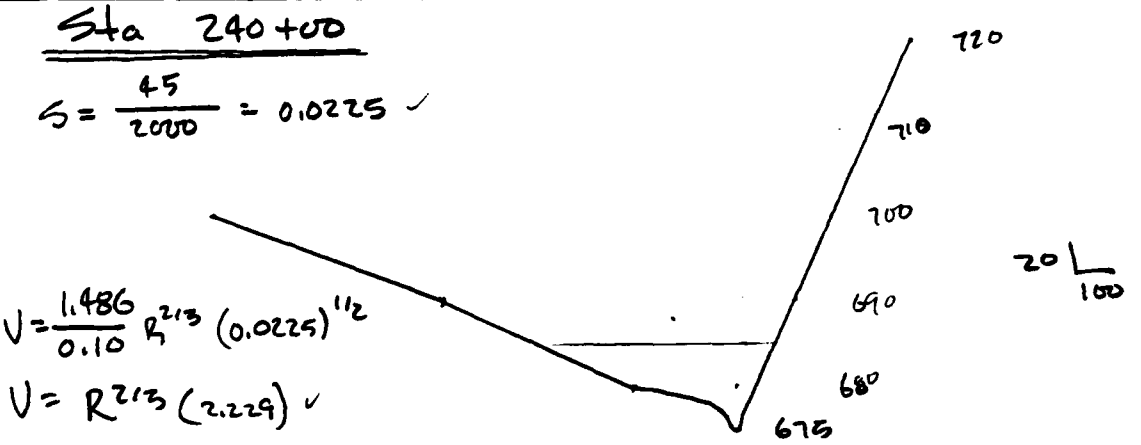
$Q_{P_3} = 14864 \left(1 - \frac{161}{1750}\right) = 13{,}497.$ ✓ $D_3 = 12.2$ ✓

Elev = 724.2 ✓

Baseflow = 2000 elev = 719.7'±
Combined = elev = 725 (13')

Sta 240+00

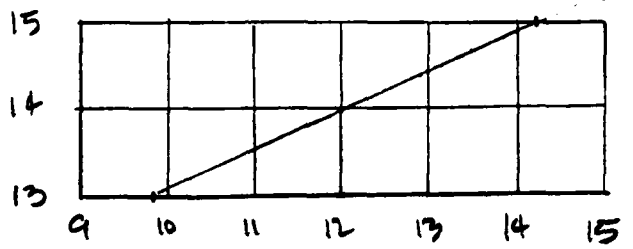
$S = \frac{45}{2000} = 0.0225$ ✓



$V = \frac{1.486}{0.10} R^{2/3} (0.0225)^{1/2}$

$V = R^{2/3} (2.229)$ ✓

D	WP	A	$R^{2/3}$	(2.229) ✓	Vel	Q; cfs
5	80	240	2.09	"	4.6	1117
10	140	740	3.05 ✓	"	6.8 ✓	5032. ✓
13	175	1210	3.65 ✓	"	8.14 ✓	9852. ✓
15	200	1590	4.01 ✓	"	8.9 ✓	14215. ✓



$Q_{P_1} = 13,497.$ $D_1 = 14.6$ ✓ $V_1 = \frac{1514 + 1800}{2}\left(\frac{2000}{43560}\right) = 76$ ✓

$Q_{1/2} = 13,497.\left(1 - \frac{76}{1750}\right) = 12910.$ ✓ $D_2 = 14.4$ ✓

$V = \frac{1476 + 1800}{2}\left(\frac{2000}{43560}\right) = 75$ ✓ $V_a = 75.5$ ✓

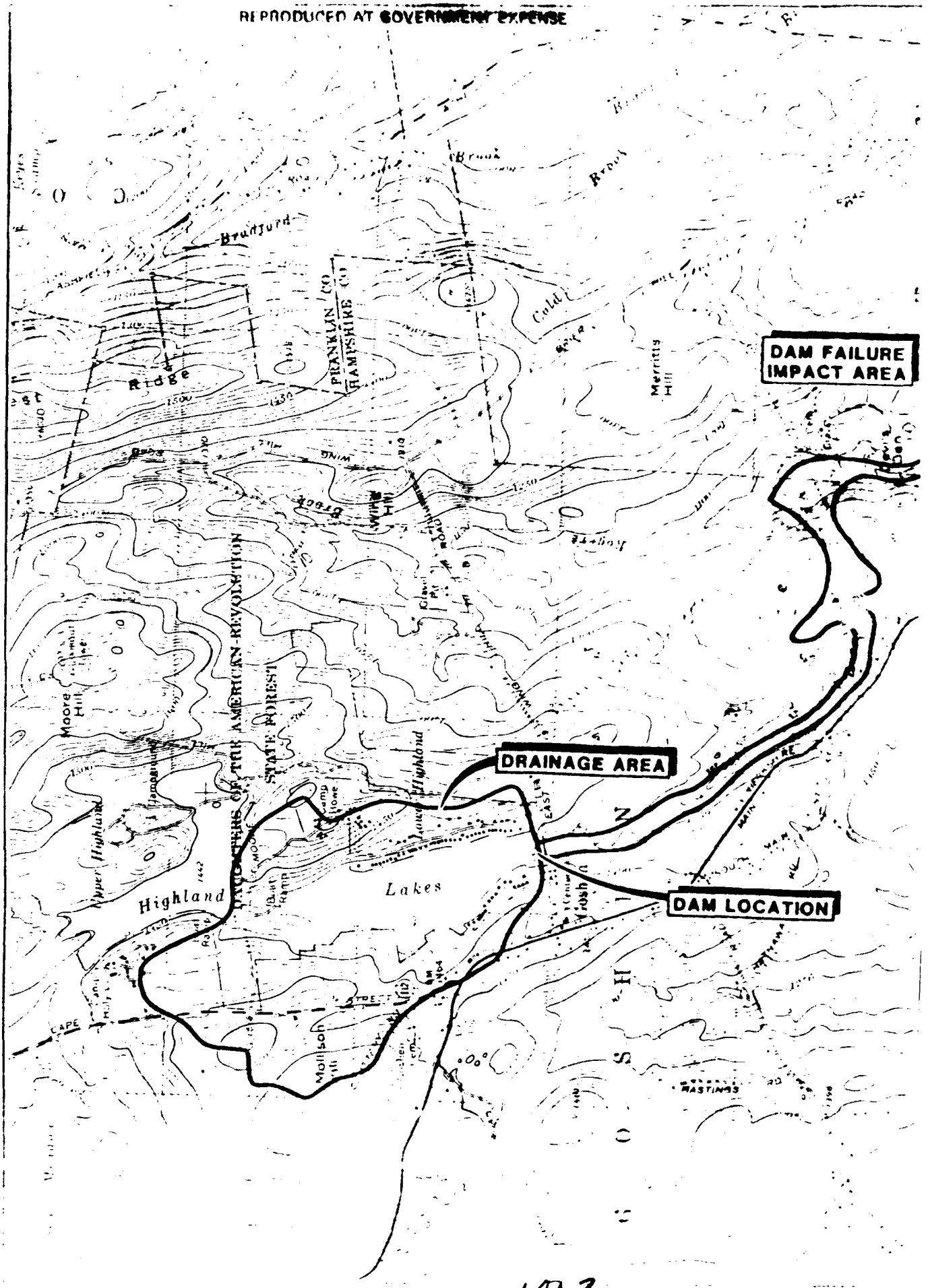
$Q_{P_3} = 13497\left(1 - \frac{75.5}{1750}\right) = 12,915.$ cfs $D = 14.4$ ✓

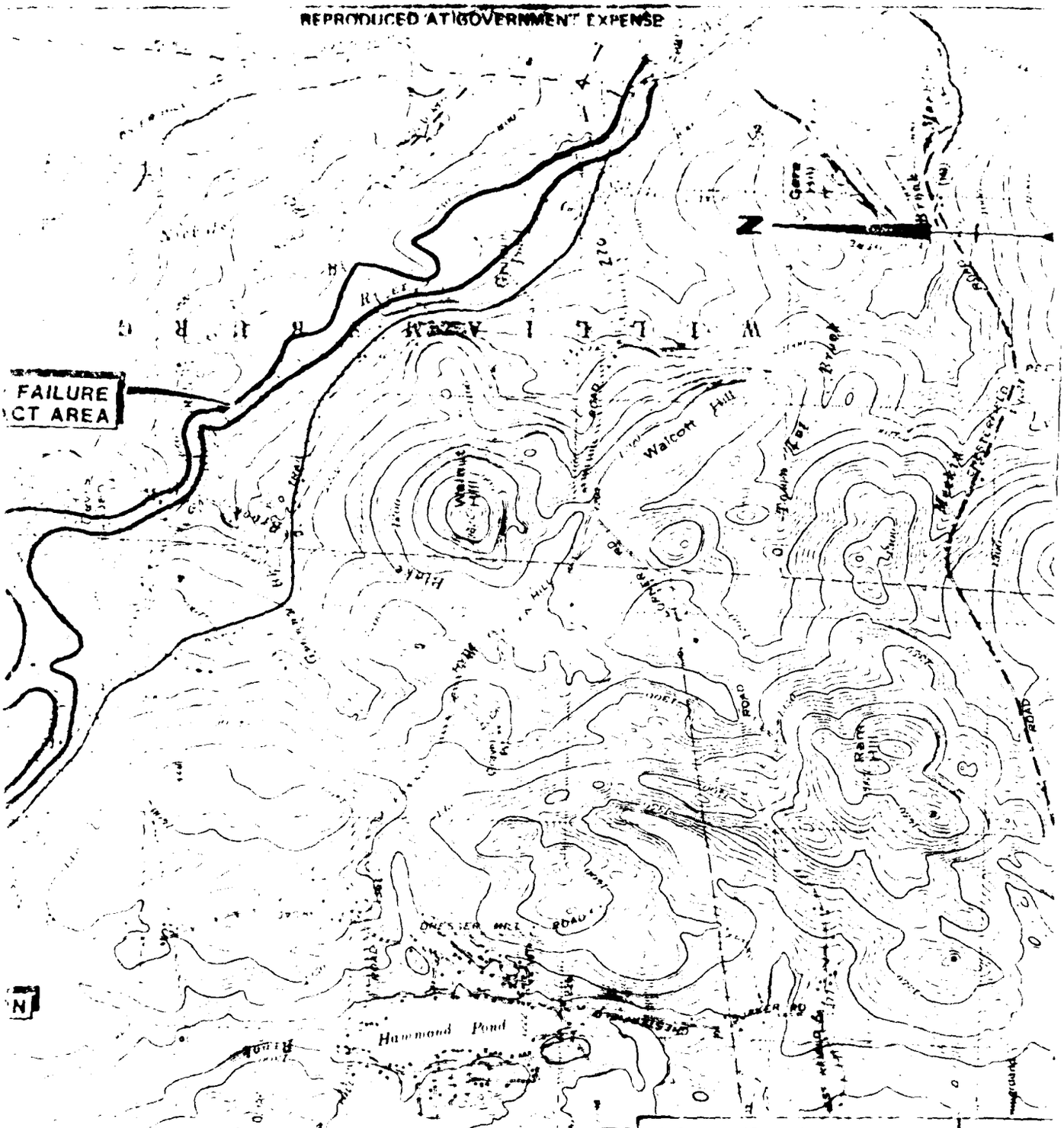
Elev = $689.4_{D=15'}$ ✓ ($690 \pm$)$^{F+B}$

Base flow + Spillway Discharge = 2100 cfs $D_B = 7' \pm$
Elev 682 ±

(15.3 + 675 = 690.3 ±)

15





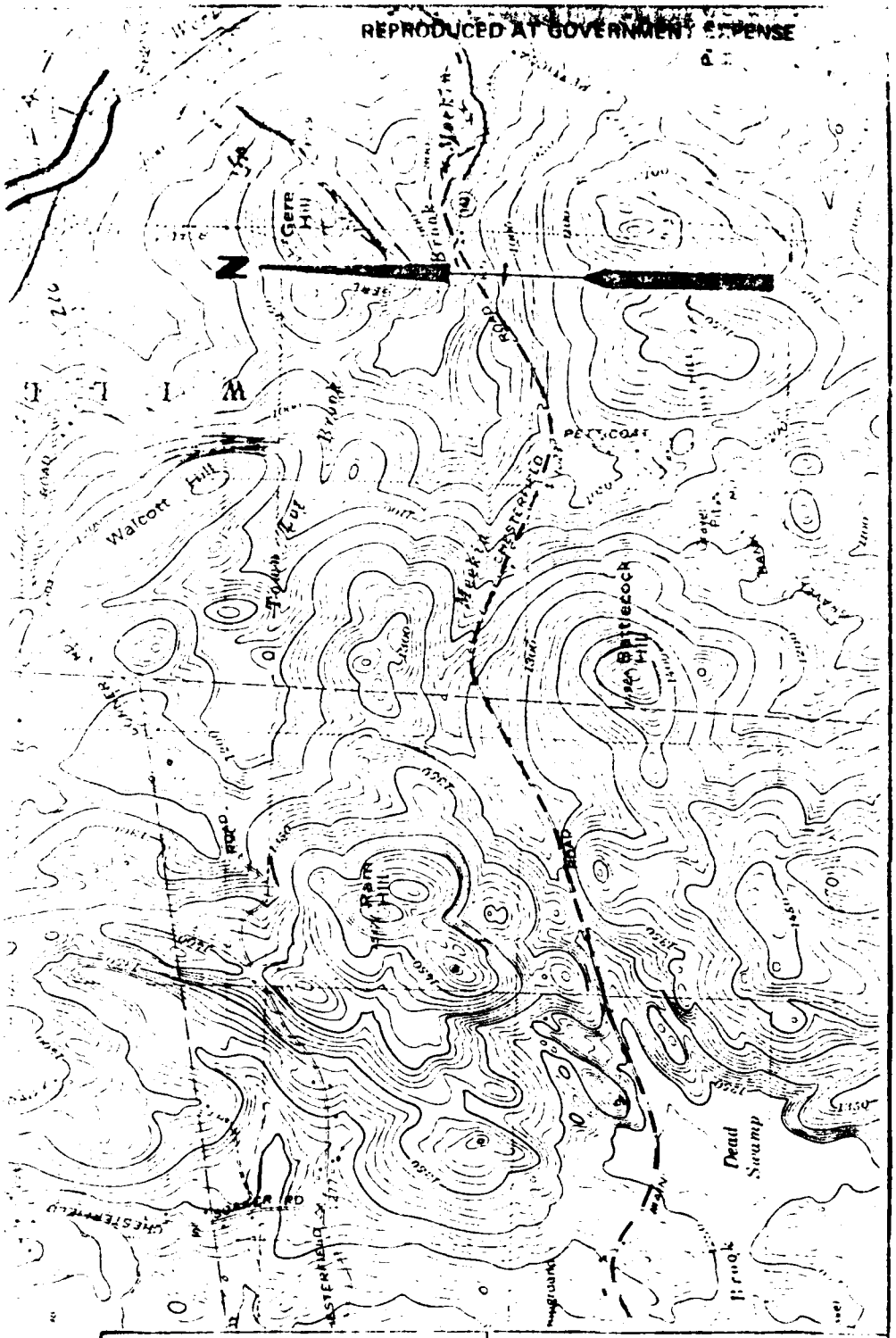
HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

US ARMY

NATIONAL PROGRAM OF INSPECTION

HIGHLAND LAKES-LOWER
DAM FAILURE IMPACT
DRAINAGE AREA

GOSHEN



HAYDEN, HARDING & BUCHANAN, INC CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	US ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

HIGHLAND LAKES - LOWER LAKE DAM
DAM FAILURE IMPACT & DRAINAGE AREA

GOSHEN

393

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME